SOCIAL DEVELOPMENT

Ian Morris

Stanford University
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http://www.ianmorris.org

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1 Introduction

In the 18th century CE, Western Europeans and their colonists on other continents began asking themselves a new question: why does the West seem to be taking over the world? And since at least the later 19th century, many of the people on the receiving end of Western commerce, colonization, imperialism, and acculturation have been wondering the same thing. Yet even now, there is little agreement on answers.

At one end of the spectrum of theories are long-term lock-in models, suggesting that the West has been fated to dominate the rest since time immemorial, thanks to its culture, climate, resources, or beliefs. At the other are short-term accident theories, arguing that nothing at all distinguished the West even as recently as 1800 CE, when lucky breaks suddenly gave it access to the power of fossil fuels and transformed the global balance of power.

The reason there is so much controversy, I suggest in *Why the West Rules—For Now* (Morris 2010), is a lack of clarity over exactly what it is we are trying to explain. Because there is no agreement on the starting point, different analysts tend to focus on different periods of the past, using different kinds of evidence, and defining the terms in different ways. It is not surprising that they come to different conclusions.

The question is really one about social development, by which I mean a group's ability to master its physical and intellectual environment to get things done. Long-term lock-in theorists tend to argue that Western social development has been higher than that in other parts of the world for many hundreds or even thousands of years; short-term accident theorists tend to argue that Western development only pulled ahead in the last half-dozen generations. If we really want to explain why the West rules, we need to measure social development and compare it across time and space. Only when we have established the basic pattern can we start asking why it takes the form it does.

In Chapter 3 and the Appendix of *Why the West Rules—For Now* (Morris 2010: 3-36, 623-45) I briefly describe the methods I used to calculate Eastern and Western social development scores from 14,000 BCE through 2000 CE, but a full account would have made an already long book even longer. In the past, historians have sometimes backed up books on broad historical questions with supplementary volumes of statistics and sources (e.g., Fogel and Engerman 1974), but it now seems more sensible to provide such a technical appendix in non-print forms. This pdf e-book supplements the printed book by explaining the methods in more detail, discussing possible objections to this approach, and providing references for the evidence behind the calculations. The same material is also available in html format at my website http://www.ianmorris.org. I have edited the html version slightly for this pdf version, reducing redundancy between sections, but the substance of the html and pdf versions is identical.

2 Formal definition

Social development is the bundle of technological, subsistence, organizational, and cultural accomplishments through which people feed, clothe, house, and reproduce themselves, explain the world around them, resolve disputes within their communities, extend their power at the expense of other communities, and defend themselves against others' attempts to extend power (Morris 2010: 144).

Since the 1990s, debates within the West over the causes and likelihood of continuance of its global domination have intensified, probably driven largely by the People's Republic of China's economic takeoff (e.g., Acemoglu and Robinson, forthcoming; Clark 2007; Diamond 1997; Frank 1998; Goldstone 2009; Landes 1998; Maddison 2003, 2005, 2007a, 2007b; North et al. 2009; Pomeranz 2000; Turchin 2003, 2009; Turchin and Nefedov 2009; Wong 1997). In varying ways, all the theories that have been offered have been arguments about social development in more or less the sense that I define it here, but this has often been left implicit. My goal in formalizing a definition of social development is to put the debate on a more explicit footing.

I want to stress that social development is *not* a yardstick for measuring the moral worth of different communities. For instance, twenty-first-century Japan is a land of air conditioning, computerized factories, and bustling cities. It has cars and planes, libraries and museums, high-tech healthcare and a literate population. The contemporary Japanese have mastered their physical and intellectual environment far more thoroughly than their ancestors a thousand years ago, who had none of these things. It therefore makes sense to say that modern Japan is more developed than medieval Japan. Yet this implies nothing about whether the people of modern Japan are smarter, worthier, or luckier (let alone happier) than the Japanese of the Middle Ages. Nor do social development scores imply anything about the moral, environmental, or other costs of social development. Social development is a neutral analytical category. Measuring social development is one thing; praising or blaming it is another altogether.

3 Core assumptions

[3.1] *Quantification*
To be useful in explaining why the West rules, social development must be quantifiable. Historians have argued for generations over the relative merits of quantitative and qualitative approaches (e.g., Elton and Fogel 1983), and I will not rehash these increasingly sterile debates. I do not claim that quantitative approaches are any more objective than qualitative ones; judgment calls and potentially arbitrary distinctions must always be made, whether we count or whether we describe. But quantitative approaches should certainly be more explicit than qualitative ones, since the act of quantification forces the analyst to focus on these decisions and to formulate reasons for choosing one option rather than another. If we do not approach social development quantitatively, the debate will continue to be bogged down in a definitional morass. The goal must be a numerical index of social development, allowing direct comparisons between different parts of the world and different periods of history.

[3.2] *Parsimony*
Albert Einstein is supposed to have said that "in science, things should be made as simple as possible, but no simpler." By contrast, humanists (including many historians) often suggest that the goal should be to add complexity to our understanding of the world. There are certainly many questions—particularly in cultural studies—that call for methods that complicate the answers and add nuance, even at the cost of clarity, but in discussions of why the West rules the main problem has generally been *too much* complexity, obscuring the central issues in masses of detail.

[3.3] *Traits*
Operationalizing a broad concept like social development requires us to break it down into smaller, directly measurable units. Following the model of the United Nations Human Development Index (http://hdr.undp.org/en/), I have tried to identify the minimum number of concrete traits that cover the full range of criteria in the formal definition of social development. No trait list can ever be perfect, but the challenge is to select the optimal set—that is asset that would fail Einstein's simplicity test if we were to add more traits, because that would make things unnecessarily complex, or if we were to subtract traits, because the list would then no longer cover the full range of elements in the definition and would *oversimplify* things.

[3.4] *Criteria*

A good trait must meet six criteria (Gerring 2001):

1) The trait must be *relevant*: that is, it must tell us something about social development.

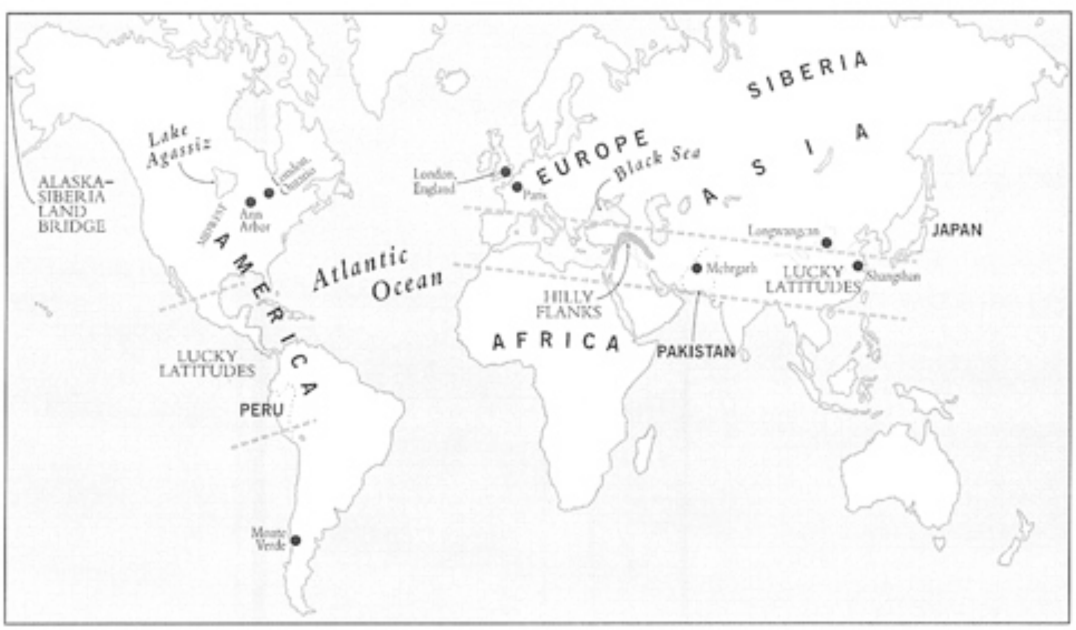
2) The trait must be *culture-independent*. We might, for example, think that the quality of literature and art are useful measures of social development, but judgments in these matters are notoriously culture-bound.

3) Traits must be *independent of each other*—if, for instance, we use the number of people in a state and the amount of wealth in that state as traits, we should not use per capita wealth as a third trait, because it is just a product of the first two traits.

4) The trait must be *adequately documented*. This is a real problem when we look back thousands of years because the evidence available varies so much. Especially in the distant past, we simply do not know much about some potentially useful traits.

5) The trait must be *reliable*, meaning that experts more or less agree on what the evidence says.

6) The trait must be *convenient*. This may be the least important criterion, but the harder it is to get evidence for something or the longer it takes to calculate results, the less useful that trait is.



Map 1. The "Lucky Latitudes" (map by Michele Angel)

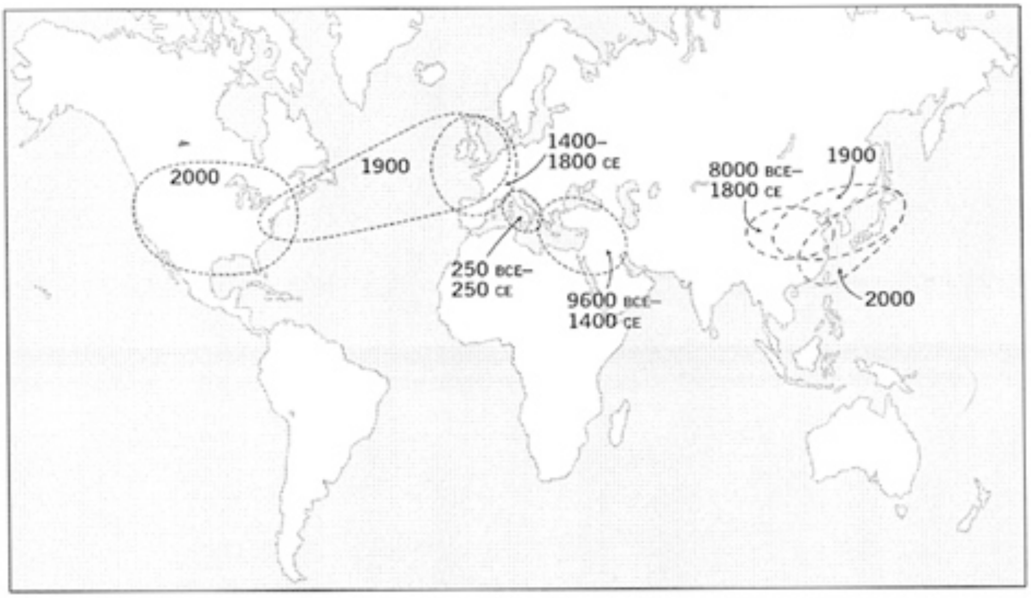
[3.5] *The focus on East and West*

A genuinely global survey of social development, reviewing in as much detail as possible every region of the world, would be very welcome. However, if we want to explain why the West rules such a book would be a very blunt tool, failing Einstein's test by adding unnecessary complexity. The core question is whether Western social development has been higher than development in the rest of the world since the distant past or whether the West has only scored higher in recent times. To answer that, we do not need to examine the social development of every region in equal detail. For reasons discussed in Jared Diamond's *Guns, Germs, and Steel* (Diamond 1997: 93-175) and in Chapter 2 of *Why the West Rules—For Now*, at the end of the Ice Age social development began rising faster in a small group of societies in the "Lucky Latitudes" (roughly 20-35° North in the Old World and 15° South to 20° North in the New; Map 1) than anywhere else on earth. The only parts of the world that could plausibly have produced rivals to the West in the past few hundred years are those that developed from cores in the New World, South Asia, and East Asia; and in reality, the only regions that have scored higher on social development than the West since the end of the Ice Age have been in East Asia. Following the principle of parsimony, I therefore focus on East-West comparisons.

[3.6] *Core regions*

As I explain in Chapter 2 of *Why the West Rules—For Now* (Morris 2010: 114-19), I define "East" and "West" as the societies that have developed from the original core areas in the headwaters of the Euphrates and Tigris Rivers and between the Yellow and Yangzi Rivers where agriculture began developing after the end of the Ice Age. Both regions have expanded spectacularly in the last ten thousand years, and as Kenneth Pomeranz (2000: 3-10) points out, comparing inappropriate parts of these areas will produce misleading results. It is therefore crucial to be consistent about comparisons.

One solution would be to look at the whole of the Eastern and Western zones, although that would mean that the Western score for, say, 1900 CE would bundle together industrialized England with Russia's serfs, Mexico's peons, and Australia's ranchers. We would then have to calculate an average development score for the whole Western region, then do it again for the East, and repeat the process for every earlier point in history. This would get so complicated as to become impractical, violating criterion 7, and would probably be rather pointless anyway. When it comes to explaining why the West rules, the most important information normally comes from comparing the most highly developed parts of each region, the cores that were tied together by the densest political, economic, social, and cultural interactions. An index of social development needs to measure and compare changes within these cores.



Map 2. The shifting locations of the Eastern and Western cores (map by Michele Angel)

As I explain in *Why the West Rules—For Now* (Morris 2010: 158-60), these core areas have shifted and changed across time (Map 2). The Western core was geographically very stable from 11,000 BCE until about 1400 CE, remaining firmly at the east end of the Mediterranean Sea except for the 500 years between about 250 BCE and 250 CE, when the Roman Empire drew it westward to include Italy. Otherwise, it always lay within a triangle between what are now Iraq, Egypt, and Greece. Since 1400 CE it has moved relentlessly north and west, first to northern Italy, then to Spain and France, then broadening to include Britain, Belgium, Holland, and Germany. By 1900 it straddled the Atlantic and by 2000 was firmly planted in North America. In the East the core remained in the original Yellow-Yangzi River zone right up till 1850 CE, although its center of gravity shifted northward toward the Yellow River's Central Plain after about 4000 BCE, back south to the Yangzi valley after 500 CE, and gradually north again after 1400. It expanded to include Japan by 1900 and southeast China too by 2000.

There will inevitably be at least some disagreement between specialists over the precise boundaries of the Eastern and Western cores at any given moment in time; I indicate approximately the areas I treat as the cores in Table 1.

Table 1 Core Regions, 14,000 BCE-2000 CE

The West

14,000 BCE: Hilly Flanks (SW Asia)
13,000 BCE: Hilly Flanks (SW Asia)
12,000 BCE: Hilly Flanks (SW Asia)
11,000 BCE: Hilly Flanks (SW Asia)
10,000 BCE: Hilly Flanks (SW Asia)
9000 BCE: Hilly Flanks (SW Asia)
8000 BCE: Hilly Flanks (SW Asia)
7000 BCE: Hilly Flanks (SW Asia)
6000 BCE: Hilly Flanks (SW Asia)
5000 BCE: Hilly Flanks (SW Asia)
4000 BCE: Mesopotamia (SW Asia)
3500 BCE: Mesopotamia (SW Asia)
3000 BCE: Egypt (NE Africa)
2500 BCE: Egypt (NE Africa), Mesopotamia (SW Asia)
2250 BCE: Egypt (NE Africa), Mesopotamia (SW Asia)
2000 BCE: Egypt (NE Africa), Mesopotamia (SW Asia)
1750 BCE: Egypt (NE Africa), Mesopotamia (SW Asia)
1500 BCE: Egypt (NE Africa), Mesopotamia (SW Asia)
1400 BCE: Egypt (NE Africa), Mesopotamia-Anatolia (SW Asia)
1300 BCE: Egypt (NE Africa), Mesopotamia-Anatolia (SW Asia)
1200 BCE: Egypt (NE Africa)
1100 BCE: Egypt (NE Africa)
1000 BCE: Egypt (NE Africa)
900 BCE: Assyria-Mesopotamia (SW Asia)
800 BCE: Assyria-Mesopotamia (SW Asia)
700 BCE: Assyria-Mesopotamia (SW Asia)
600 BCE: Egypt (NE Africa), Mesopotamia (SW Asia)
500 BCE: Persian Empire (SW Asia)
400 BCE: Persian Empire-Aegean (SW Asia-NE Africa-SE Europe)
300 BCE: Hellenistic kingdoms (SW Asia-NE Africa-SE Europe)
200 BCE: Mediterranean basin (SW Asia-NE Africa-SE Europe)
100 BCE: Central Mediterranean (S Europe)
1 BCE/CE: Central Mediterranean (S Europe)
100 CE: Central Mediterranean (S Europe)
200 CE: Central Mediterranean (S Europe)
300 CE: Eastern Mediterranean (SW Asia-NE Africa-SE Europe)
400 CE: Eastern Mediterranean (SW Asia-NE Africa-SE Europe)
500 CE: Eastern Mediterranean (SW Asia-NE Africa-SE Europe)
600 CE: Eastern Mediterranean (SW Asia-NE Africa-SE Europe)
700 CE: Egypt (NE Africa), Syria-Iraq (SW Asia)
800 CE: Egypt (NE Africa), Syria-Iraq (SW Asia)

900 CE: Egypt (NE Africa), Spain (SW Europe)
1000 CE: Mediterranean basin (SW Asia-N Africa-S Europe)
1100 CE: Mediterranean basin (SW Asia-N Africa-S Europe)
1200 CE: Mediterranean basin (SW Asia-N Africa-S Europe)
1300 CE: Mediterranean basin (SW Asia-N Africa-S Europe)
1400 CE: Mediterranean basin (SW Asia-N Africa-S Europe)
1500 CE: Atlantic littoral (W Europe)
1600 CE: Atlantic littoral (W Europe)
1700 CE: France, Britain, Netherlands (NW Europe)
1800 CE: France, Britain (NW Europe)
1900 CE: Germany, France, Britain, USA (N Europe, N America)
2000 CE: USA (N America)

<u>The East</u>
14,000 BCE: Yellow-Yangzi river valleys (China)
13,000 BCE: Yellow-Yangzi river valleys (China)
12,000 BCE: Yellow-Yangzi river valleys (China)
11,000 BCE: Yellow-Yangzi river valleys (China)
10,000 BCE: Yellow-Yangzi river valleys (China)
9000 BCE: Yellow-Yangzi river valleys (China)
8000 BCE: Yellow-Yangzi river valleys (China)
7000 BCE: Yellow-Yangzi river valleys (China)
6000 BCE: Yellow-Yangzi river valleys (China)
5000 BCE: Yellow-Yangzi river valleys (China)
4000 BCE: Yellow-Yangzi river valleys (China)
3500 BCE: Yellow-Yangzi river valleys (China)
3000 BCE: Yellow-Yangzi river valleys (China)
2500 BCE: Yellow-Yangzi river valleys (China)
2250 BCE: Yellow-Yangzi river valleys (China)
2000 BCE: Yellow River valley (China)
1750 BCE: Yellow River valley (China)
1500 BCE: Yellow River valley (China)
1400 BCE: Yellow River valley (China)
1300 BCE: Yellow River valley (China)
1200 BCE: Yellow River valley (China)
1100 BCE: Yellow River valley (China)
1000 BCE: Yellow River valley (China)
900 BCE: Yellow River valley (China)
800 BCE: Yellow River valley (China)
700 BCE: Yellow River valley (China)
600 BCE: Yellow River valley (China)
500 BCE: Yellow-Yangzi river valleys (China)
400 BCE: Yellow-Yangzi river valleys (China)
300 BCE: Yellow-Yangzi river valleys (China)
200 BCE: Yellow-Yangzi river valleys (China)
100 BCE: Yellow-Yangzi river valleys (China)
1 BCE/CE: Yellow-Yangzi river valleys (China)

100 CE: Yellow-Yangzi river valleys (China)
200 CE: Yellow-Yangzi river valleys (China)
300 CE: Yangzi River valley (China)
400 CE: Yangzi River valley (China)
500 CE: Yangzi River valley (China)
600 CE: Yellow-Yangzi river valleys (China)
700 CE: Yellow-Yangzi river valleys (China)
800 CE: Yellow-Yangzi river valleys (China)
900 CE: Yangzi River valley (China)
1000 CE: Yellow-Yangzi river valleys (China)
1100 CE: Yellow-Yangzi river valleys (China)
1200 CE: Yellow-Yangzi river valleys (China)
1300 CE: Yellow-Yangzi river valleys (China)
1400 CE: Yellow-Yangzi river valleys (China)
1500 CE: Yellow-Yangzi river valleys (China)
1600 CE: Yellow-Yangzi river valleys (China), Japan
1700 CE: Yellow-Yangzi river valleys (China)
1800 CE: Yellow-Yangzi river valleys (China)
1900 CE: Japan
2000 CE: Eastern China, Japan

[3.7] *Measurement intervals*

Following the principle of parsimony, social development scores should be calculated at chronological intervals short enough to illustrate the broad pattern of change but no shorter. In prehistory, dating techniques often involve broad margins of error, but the rate of social change was often very slow. Even if we had good enough evidence to distinguish between social development in (say) 14,000 BCE and 13,900 BCE, the difference would probably be too small to measure. I therefore use a sliding interval. From 14,000 through 4000 BCE, I measure social development every 1,000 years. From 4000 through 2500 BCE the quality of evidence improves and change accelerates, so I measure every 500 years. I reduce this to every 250 years between 2500 BCE and 1500 BCE, and finally measure every century from 1400 BCE through 2000 CE. In the twentieth century CE the quality of data would allow us to trace changes just year-by-year or even (at least in the second half of the century) month-by-month if we wanted to, but this level of precision does little to answer the question of why the West rules while adding enormously to the effort of quantification, violating criterion 7.

[3.8] *Approximation and falsification*

There is no such thing as an index that is 100 percent accurate, whether we interpret "accurate" in the strong sense that every single detail is absolutely correct or the weaker sense that all experts will make exactly the same estimates, even if they cannot prove that these estimates are correct. In all historical scholarship there is little we can be completely sure about and even less that experts will agree on. As a result, I take it for granted that there is no point in asking whether the social development scores I calculate contain mistakes. Of course they do. The only meaningful question is: *how* wrong are they? Are they so wrong that I have misidentified the basic shape of the history of social development, meaning that my explanation for why the West rules is fatally flawed? Or are the errors in fact relatively trivial?

There are two main ways to address these questions. One is to assume that I have made systematic errors, pervasively overestimating the Western and underestimating the Eastern scores (or vice versa), then to ask (1) how much we would need to change the scores to make the past look so different that the arguments advanced in *Why the West Rules—For Now* would cease to hold good and (2) whether such changes are plausible. The other is to assume that the errors are unsystematic, over- or underestimating both the Eastern and Western scores in random, unpredictable ways. The only way to address errors of this kind is to work through the references provided on this website for energy capture, organization, war-making, and information technology, and, and then to show either (1) that different scores are more accurate, (2) that alternative traits work better, (3) that alternative geographical cores score higher, or (4) that the whole exercise of calculating a social development index is flawed.

4 Core Objections

I see four main objections to the social development index:

1. Quantifying and comparing social development in different times and places dehumanizes people and we should therefore not do it.
2. Quantifying and comparing societies is a reasonable procedure, but social development in the sense I defined it (as societies' abilities to get things done) is the wrong thing to measure.
3. Social development in the sense I defined it is a useful way to compare east and west, but the four traits I use to measure it (energy capture, organization/urbanization, war-making, and information technology) are not the best ones.
4. These four traits are a good way to measure social development but I have made factual errors and got the measurements wrong.

[4.1] *Dehumanization*

Quantifying and comparing social development in different times and places dehumanizes people and we should therefore not do it.

This argument has been influential in cultural history and anthropology since at least the 1960s, for reasons I discuss in Chapter 3 of *Why the West Rules—For Now* (Morris 2010: 135-42). There are certainly plenty of historical and anthropological questions for which quantifying and comparing social development is no help at all, but asking why the West rules is by its nature a comparative and quantitative question. If we want to answer it, we must quantify and compare.

[4.2] *Inappropriate definition*

Quantifying and comparing societies is a reasonable procedure, but social development in the sense I defined it (as societies' abilities to get things done) is the wrong thing to measure.

The only way to address this objection would be for a critic to try to show that there are other things we could measure and compare that would be more helpful than social development in the sense I define it for explaining why the West rules. I do not know what these other things might be, so I leave it to other historians and anthropologists to identify them and to show that they yield more useful results.

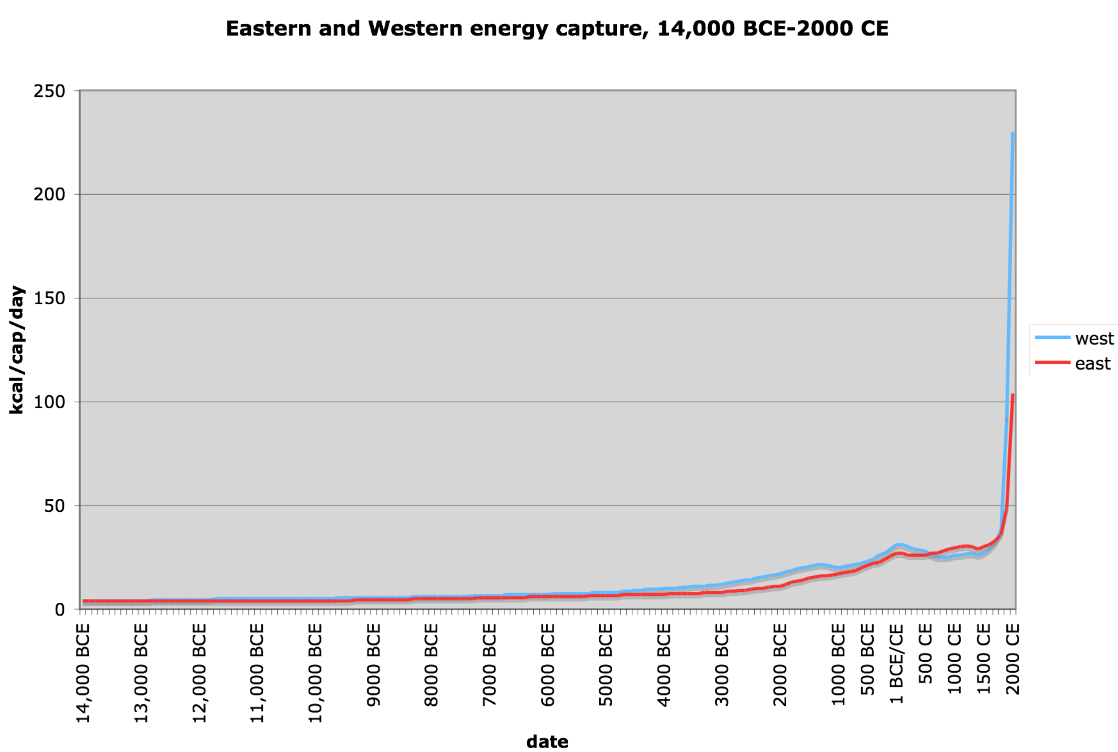
[4.3] *Inappropriate traits*

Social development in the sense I defined it is a useful way to compare east and west, but the four traits I use to measure it (energy capture, organization/urbanization, war-making capacity, and information technology) are not the best ones.

This objection can take three forms.

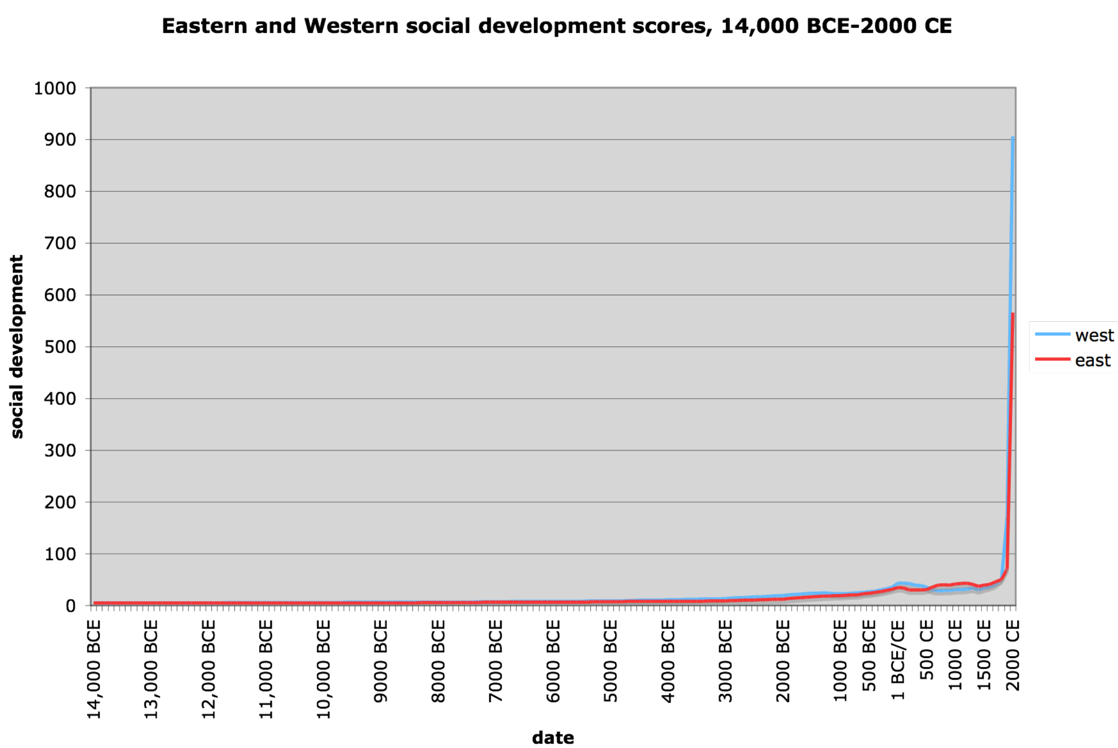
(i) We should add more traits to my four traits of energy capture, organization, war-making capacity, and information technology. But while there are certainly many traits we could examine, the principle of parsimony dictates that we should avoid adding more traits to the minimum set that covers the full range of what is meant by social development.

(ii) We should use different traits. Again, there are certainly other variables we could measure, but all the alternatives that I have examined perform poorly on various criteria, having severe empirical problems or lacking in mutual independence. Most traits in any case show high levels of redundancy through most of history, and any plausible combination of alternative traits will tend to produce much the same final result.



Graph 1. Eastern and Western energy capture, 14,000 BCE-2000 CE

(iii) We should look at fewer traits. In view of the redundancy between the four traits, we might drop some of them, increasing parsimony. The obvious strategy would be to drop organization, war-making capacity, and information technology, and concentrate only on energy capture, on the grounds that organization, war-making, and information technology are merely ways of *using* energy (Morris 2010: 625-26). Graph 1 shows what an energy-alone index would look like. It is different from Graph 2, showing the full index, but not hugely so. In the energy-alone graph, just like the full social development graph, the West still leads the East for 90 percent of the time since the late Ice Age; the East still overtakes the West between roughly 550 and 1750 CE; there is still a hard ceiling that blocks development around 100 and 1100 CE (at just over 30,000 kilocalories per person per day); post-industrial revolution scores still dwarf those of earlier ages; and in 2000 CE the West still rules.



Graph 2. Eastern and Western social development scores, 14,000 BCE-2000 CE, shown on a linear-linear scale

But while focusing on energy alone has the advantage of increasing parsimony, it also has one great drawback. The four traits I use are not *completely* redundant, and since the industrial revolution the relationship between energy capture and the other traits has become non-linear.

Increases at the margins of energy capture have produced vastly greater increases in energy use in selected fields, because human energy use is highly elastic relative to energy capture. Thanks to new technologies, city-size quadrupled across the twentieth century, war-making capacity increased fifty-fold, and information technology surged eighty-fold, while energy capture per person merely doubled. Looking at energy alone fails Einstein's test by being *too* simple, and distorts the shape of history.

[4.4] *Empirical errors*

These four traits are a good way to measure social development but I have made factual errors and got the measurements wrong.

As noted in the discussion of approximation and falsification, there are two main ways to address this objection. One is to assume that I have made systematic errors, pervasively overestimating the Western and underestimating the Eastern scores (or vice versa), then to ask (1) how much we would need to change the scores to make the past look so different that the arguments advanced in *Why the West Rules—For Now* would cease to hold good and (2) whether such changes are plausible. The other is to assume that the errors are unsystematic, over- or underestimating the Eastern and/or Western scores in random, unpredictable ways. The only way to address errors of this kind is to work through the references provided in this book for energy capture, organization, information technology, and war-making capacity, and then to show either (1) that different scores are more accurate, (2) that alternative traits work better, (3) that alternative geographical cores score higher, or (4) that the whole exercise of calculating a social development index is flawed.

5 Models for an index of social development

As far as possible, this index of social development builds on existing scholarship, particularly the indices developed in neo-evolutionary anthropology, mostly in the 1950s-70s, and the United Nations' Human Development Index, developed since 1990. The anthropologists, archaeologists, economists, and political scientists involve in these projects have already identified numerous pitfalls and problems and offered solutions to many of them.

[5.1] *Social development indices in neo-evolutionary anthropology*
In 1949 the Human Relations Area Files (HRAF; http://www.yale.edu/hraf/) were established at Yale University to create a database for global comparisons of human behavior, society, and culture (Ember 1997; Ember and Ember 2001), and in the 1950s a number of anthropologists began using HRAF or other datasets to build cross-cultural indices of social development (e.g., Bowden 1969; Carneiro 1962, 1968, 1969, 1970; Erickson 1972; Freeman and Winch 1957; McNett 1970a, 1970b, 1973; Murdock and Provost 1973; Naroll 1956, 1970; Sawyer and Levine 1966; Tatje and Naroll 1970).

These indices received severe criticism in the 1970s-80s (e.g., McGuire 1983; Shanks and Tilley 1987). Much, though not all, of this was justified (I expand on my views in Morris 2009), but regardless of the theoretical and methodological shortcomings of some of their writings, the early neo-evolutionists did identify most of the basic problems in index-building (e.g., how to reduce a mass of information to a small number of traits, how to weight the traits, how to define key terms like differentiation, and how to define the unit of analysis). They rarely agreed on how to solve these problems, but nevertheless developed sufficiently robust techniques that they could agree on scores 87-94 percent of the time (Carneiro 2003: 167-68).

The neo-evolutionary indices differ from the index developed here in two main ways. First, they normally aim at creating general-purpose score sheets summarizing cultural complexity. This is very different from an index rather than at answering a specific question like why the West rules. No two anthropologists agree on exactly how to define cultural complexity, but most connect it to differentiation, the central concept developed by Herbert Spencer (1857). To take just a handful of frequently cited examples, cultural complexity "can be measured in terms of [a system's] segregation (the amount of internal differentiation and specialization of subsystems) and centralization (the degree of linkage between the various subsystems and the highest-order controls in society …)" (Flannery 1972: 409); is "the extent to which there is functional differentiation among societal units" (Blanton et al. 1981: 21); "refer[s] to such things as the size of a society, the number and distinctiveness of its parts, the variety of specialized social roles that it incorporates, the number of distinct social personalities present, and the variety of mechanisms for organizing these into a coherent, functioning whole" (Tainter 1988: 23); means "pronounced and institutionalized patterns of inequality and heterogeneity" (A. Smith 2003: 5-6); or is "the emergence and proliferation of sets of systems of subsystems that are distinguished from those present in simpler societies by relatively more differentiated and advanced internal structures" (R. M. Adams 2001: 355).

These definitions connect only indirectly to social development as defined for the purposes of explaining why the West rules, which means that none of the traits chosen by neo-evolutionists exactly matches our needs.

The second problem with the neo-evolutionary approaches is that they normally offer synchronic snapshots of individual cultures at single moments in time. Since the main way that social development helps us explain why the West rules is by allowing us to measure how Eastern and Western development scores changed over time, the methods of measurement created by neo-evolutionists will not be very helpful.

In sum, the index of social development described here depends heavily on the work of neo-evolutionary anthropologists, chiefly in the 1950s-70s. It also takes account of the perceptive criticisms of anthropologists in the 1980s, and differs in significant ways from its neo-evolutionist predecessors, particularly in measuring a more narrowly defined concept of social development that is tailored toward answering the specific question of why the West rules and in allowing measurement of change through time as well as contrasts through space.

[5.2] *The United Nations Human Development Index*

The first Human Development Index; http://hdr.undp.org/en/) was designed in 1990 by the Pakistani economist Mahbub ul Haq with the aim of shifting development economists' focus from national income accounting toward actual human wellbeing (ul Haq 1995). Working with Amartya Sen and a team of United Nations economists, ul Haq crafted the HDI to provide a single score that would tell development officers how well each country was doing in allowing its citizens to fulfill their innate potential.

The HDI uses three traits: life expectancy at birth (e_0); knowledge and education (with adult literacy rates accounting for two-thirds of the score and enrollment in schools and universities for the other one-third); and standard of living (gross domestic product per capita [GDP/cap] measured in US$ at purchasing power parity rates [PPP]). The UN Human Development Programme provides a convenient calculator for generating scores (http://hdr.undp.org/en/statistics/faq/question,68,en.html).

The HDI has been criticized for everything from its selection of traits and the way it weights education and income to its neglect of ecology and morality (e.g., Hastings; McGillivray 1991; McGillivray and White 2006; Sagara and Najam 1998; Srinivasan 1994), but it remains one of the most widely used indices.

Human development is of course different from social development as defined here, but the basic principle of identifying a small number of quantifiable core traits is transferable. The HDI *can* be used to measure change through time, simply by comparing a country's score in each annual report, but because the maximum possible score is 1.0, the HDI does better at charting a nation's relative position within the world at a single point in time than at measuring diachronic changes in development levels.

In sum, while the principles behind the HDI are good models for constructing a social development index, it is less helpful as a guide to calculating changes through time, a central requirement for explaining why the West rules.

6 Trait selection

No single quantifiable trait can cover the full range of social development as defined here, but a combination of four traits—energy capture, organization, information technology, and war-making capacity—does seem to do so, and each of the traits performs relatively well on the six criteria for adequacy.

Energy capture is the foundation of social development. At the lowest level, insufficient energy capture (for adult humans, roughly 2,000 kilocalories per adult per day, varying with body size and activity level) means that individuals slow down, lose body functions, and eventually die. To clothe, house, and reproduce themselves, and to extend their power at the expense of other communities, however, humans have to capture more energy (in the case of the US in 2000 CE, for instance, around 230,000 kilocalories per person per day). Energy capture must be the starting point for any discussion of social development.

Organization is also crucial. To be able to deploy energy for food, clothing, housing, reproduction, defense, and aggression, humans have to be able to organize it. Just as organisms break down without energy, societies break down without organization.

War-making capacity is also indispensable as a measure of social development. Societies, like the individual humans within them, compete for energy, and must be able to act both defensively and aggressively. As Mao Zedong famously put it in his essay *On Protracted War*, "Every communist must grasp this truth: 'Political power grows out of the barrel of a gun'."

Finally, information technology is, again, crucial for social development. Complex life forms depend on brains to make sense of the world around them; modern humans depend on language to communicate their unique levels of understanding; and the developed societies of the past five millennia have depended on still more sophisticated technologies like writing, mathematics, and mechanical, electrical, and electronic reproduction and transmission to store and share knowledge.

These four traits do not add up to a comprehensive picture of Eastern and Western society across the last 16,000 years, any more than the UN's traits of life expectancy, education, and income tell us everything there is to know about human development, but that is not what they are supposed to do. The goal is that together they should give us a usable snapshot of social development, revealing the long-term patterns that need to be explained if we are to know why the West rules.

7 Methods of calculation

Using the four traits of energy capture, organization, war-making capacity, and information technology, we need to devise an index that can assign scores to the geographical cores in East and West at defined chronological intervals.

For reasons discussed in Chapters 2-3 of *Why the West Rules—For Now*, I begin my index near the end of the last Ice Age, in 14,000 BCE, and for the sake of convenience treat the year 2000 CE as its end point. Sticking to the principle of parsimony, I set 1,000 points as the maximum social development score attainable in 2000 CE. Unlike the United Nations' Human Development Index, however, I do not treat 1,000 points as an absolute ceiling; by 2010 CE Western social development has already risen well above this level, and, as I explain in Chapter 12 of the book, there is good reason to expect both Eastern and Western social development to reach at least 5,000 points by 2100 CE. One thousand points is simply a convenient number for organizing the index.

When the neo-evolutionist Raoul Naroll published the first modern index of social development, he gave equal points to each of his traits, if only, as he put it, "because no obvious reason appeared for giving one any more weight than another" (Naroll 1956: 691). Naroll's principle remains valid, so I divide my 1,000 points equally between the four traits, so that the society that scores highest on each trait in the year 2000 CE receives 250 points for it, and other societies receive points proportionate to their performance on that trait. (Even if there were good reasons to weight one trait more heavily than another, there would be no grounds to assume that the same weightings have held good across the 16,000 years under review, or have applied equally to East and West.)

Thus for energy capture the West earned 250 points in 2000 CE because in its core area, the United States, each person consumed on average 230,000 kilocalories per day. The East scores 113.04 points because in its core area, in Japan, each person consumed on average 104,000 kilocalories per day (I calculate scores to two decimal points because in premodern times the scores on all traits were very small indeed). Energy capture in 1900 CE is more difficult to calculate, but consumption in the Western core (in northwest Europe and the northeast US) seems to have been around 92,000 kcal/cap/day, for 100.00 points. In the Eastern core (Japan) it was roughly 49,000 kcal/cap/day, scoring 53.26 points. Moving back to 1800 CE, the margin of error of course increases, but the scores clearly fall. I estimate Western consumption in the British core around

38,000 kcal/cap/day, or 41.30 points, and Eastern consumption in the urban core in the Yangzi delta around 36,000 kcal/cap/day, or 39.13 points.

By calculating energy capture all the way back to 14,000 BCE, performing similar calculations for the other three traits, and then adding up the scores for each date we can plot Eastern and Western social development across the last 16,000 years. This literally reveals the shape of the history that we need to explain to know why the West rules—for now.

8 Energy capture

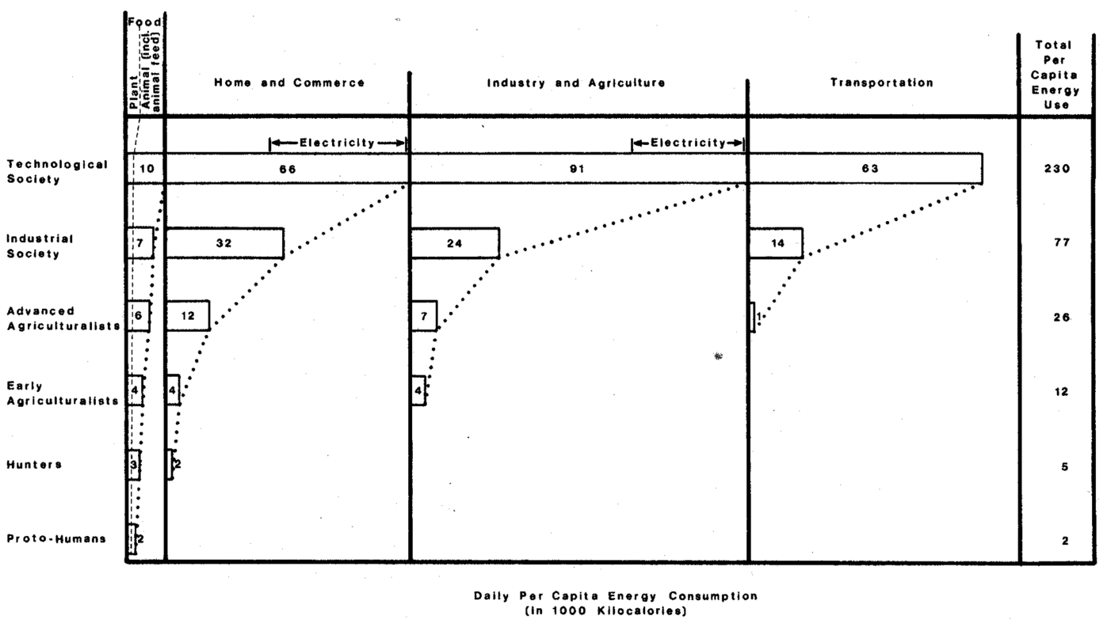
[8.1] *Energy capture, real wages, and GDP, GNP, and NDI per capita*
Energy capture is the foundation for any discussion of social development. It is related to, but broader than, measures of physical wellbeing such as real wages, gross domestic product per capita (GDP/cap), gross national product per capita (GNP/cap), or national disposable income per capita (NDI/cap). Real wages measure individual incomes (whether earned in cash or kind) corrected for inflation; GDP measures expenditure, value added in production, and income generated within the territory of a country; GNP measures GDP plus or minus net receipts from transfers of property or labor income from the rest of the world; and NDI measures GNP plus or minus net current transfers received in money or in kind from the rest of the world, including taxes and tribute, whether paid in cash or kind. GDP, GNP, and NDI are converted into per capita figures by simply dividing each by the number of people in the territory under study.

Real wages and GDP, GNP, and NDI per capita are more commonly used by economists than energy capture, largely because they are much better documented in the statistics available for modern (i.e., post-1800 CE Western, post-1900 CE Eastern, and post-1950 CE for the rest of the world) economies. Nevertheless, energy capture is a much more flexible measure for comparing very large stretches of time, across which the nature of subsistence practices changed dramatically.

All living things need to combat the forces of entropy by capturing energy from their environments. "Energy capture" describes the full range of energy captured by humans in any form whatsoever, including, but not limited to:

Food (whether consumed directly, given to animals that provide labor, or given to animals that are subsequently eaten)
Fuel (whether for cooking, heating, cooling, firing kilns and furnaces, or powering machines, and including wind and waterpower as well as wood, coal, oil, gas, and nuclear power)
Raw materials (whether for construction, metalwork, pot making, clothing, or any other purpose)

In a widely reprinted diagram (Graph 3) originally published in *Scientific American* magazine in 1971, geoscientist Earl Cook of Texas A&M University offered rough estimates of typical per person energy capture among hunter-gatherers, early agriculturalists (by which he meant the farmers of southwest Asia around 5000 BCE), advanced agriculturalists (those of northwest Europe around 1400 CE), industrial folk (west Europeans around 1860), and the "technological" societies of North America and Western Europe in the 1970s CE. He divided each score into the four categories of food (including animal feed), home and commerce, industry and agriculture, and transportation. This diagram has become a regular point of departure for world historians discussing of the history of energy capture, and I have followed in this tradition.



Graph 3. Earl Cook's (1971) diagram of energy consumption at different stages of social development

Cook's food/non-food energy distinction is fundamental. Human consumption of food energy is tightly constrained: if it falls much below an average of 2,000 kilocalories per person per day (kcal/cap/day) for any length of time, people will become unable to work, lose body functions, and die prematurely. If it stays much above 3,000 kcal/cap/day for any length of time, people will become obese, suffer serious health complications, and again die prematurely. (Nutritionists normally use "calories" to describe what physicists would call nutritional kilocalories, and the caloric content listed in "Nutrition facts" on food packaging actually refers to kilocalories.)

Consumption of food energy has changed over time in part because people have shifted back and forth between "cheap" calories such as grains and "expensive" calories such as meat (as a rough measure, it takes about ten calories of feed to grow one calorie of meat). Meat-rich 21st century diets typically represent about 10,000 kcal/cap/day. Consumption of energy in non-food forms, however, has changed much more dramatically. Most hunter-gatherers consume rather few non-food calories: they need biomass for cooking fuel, clothes, weapons, baskets, and personal ornaments, but typically have only very simple shelters and no substantial material goods. Peasant societies normally have much more substantial homes and a wide range of artifacts, and modern industrial societies of course produce non-food goods in extraordinary quantities. Total (i.e., food + non-food) energy capture in the simplest tropical hunter-gatherer societies can be as low as 4,000-5,000 kcal/cap/day; in the contemporary USA it has reached 230,000 kcal/cap/day.

Through most of history per capita non-food energy capture has tended to rise, but people have had few ways to convert non-food calories into food. As a result, the difficulty of increasing food calories has been the major brake on rising living standards. Thomas Malthus already recognized this in his *Essay on the Principle of Population*: "It should be remembered always," he wrote, "that there is an essential difference between food and those wrought commodities, the raw materials of which are in great plenty. A demand for these last will not fail to create them in as great a quantity as they are wanted. The demand for food has by no means the same creative power" (Malthus 1798: Chapter 5). Even in prehistoric times non-food energy could slightly loosen the constraints on food supply, for instance by providing manure (e.g., Bogaard et al. 2007) or by improving transport that could move food from places where it was plentiful to those where it was scarce and giving them fuel to process it, but only since the nineteenth century CE (ironically, beginning during Malthus' lifetime) have transport, processing, fertilizers, and scientific interventions revolutionized the food supply, relentlessly increasing stature, life expectancy, and health (e.g., Fogel 2004).

Despite its prominence in Malthus' and Cook's work, social scientists interested in long-term economic history regularly ignore the food/non-food calories distinction and, focusing solely on food, conclude that between the invention of agriculture more than 10,000 years ago and the industrial revolution 200 years ago not very much happened. One of the most widely cited recent discussions explicitly suggests that "the average person in the world of 1800 [CE] was no better off than the average person of 100,000 BC" (Clark 2007: 1). This is mistaken. As Malthus recognized, if good weather or technological/organizational advances raised food output, population did tend to expand to consume the surplus, forcing people to consume fewer and cheaper food calories; but despite the downward pressure on per capita food supply, increases in non-food energy capture have, in the long run, steadily accumulated.

Cook suggested that while typical hunter-gatherers captured just 2,000 kcal/cap/day of non-food energy, early farmers raised this to 8,000 kcal/cap/day, and advanced preindustrial farmers to 20,000 kcal/cap/day. My own reconstruction suggests that in the long run (passing over several periods of collapse), non-food energy capture rose steadily across the thirteen millennia after the end of the ice age around 12,700 BCE, until in Roman Italy—the core of the most advanced ancient agrarian empire—it may have reached 25,000 kcal/cap/day. This seems to have been the ceiling on what was possible in a preindustrial society, corresponding to the boundary between what E. A. Wrigley (1988) called advanced organic economies and fossil-fuel economies. For nearly 2,000 years agrarian empires pressed against this ceiling without breaking it; only in the 18th century, when British entrepreneurs learned to convert the energy released by burning coal from heat into motion, did non-food energy capture increase so much that it could in turn be converted into food calories, freeing humans from the Malthusian trap.

Cook's estimates are of course only a starting point, since he offered just six data points (proto-humans, hunters, early agriculturalists, advanced agriculturalists, industrial society, technological society), and made no attempt to distinguish between different parts of the world. He also provided no sources for his estimates. There is certainly no shortage of writings on energy consumption in history, anthropology, geography, and development economics, against which his estimates can be checked (as just a few examples from the truly enormous literature, see Adams 1996; Allen 2001, 2006, 2009a, 2009b; Allen et al. 2005; Bailey 1991; Bairoch 1982; Bengtsson et al. 2005; Boserup 1965, 1981; Braudel 1981; Chayanov 1986; Cipolla 1993; Clark and Haswell 1970; Crafts 1985; Crosby 2006; de Vries and van der Woude 1997; Dwyer 1983; Dyer 1989; Fogel 2004; Forbes 1976, 1982; Goudsblom et al. 1996; Graham et al. 2007; Johnson and Earle 2000; Katzmaryk et al. 2005; Le Roy Ladurie 1966; R. Lee 1979; Leonard and Robertson 1992; Maddison 2003; Milanovic et al. 2007; Perkins 1969; Scheidel 2010a, 2010b, 2010c; Scheidel et al. 2007; Silberbauer 1981; Singer et al. 1954-57; Slicher van Bath 1963; Smil 1983, 1991, 1994, 2008; Sørenson 2009; Woolgar et al. 2009; Wrigley 1988), but the task is complicated by the fact that the various researchers focus on different dimensions of energy capture (e.g., food consumption, net energy use, material standards of living, total consumption), measure it in different ways (e.g., kcal/cap/day, life expectancy at birth, real wages, stature), or describe changes qualitatively rather than quantifying them.

In reconstructing Western and Eastern energy capture I have therefore proceeded by using Cook's figures as points of departure, establishing an order of magnitude for "normal" consumption in a given energy regime and then using more detailed evidence to estimate how far from these normal figures the actual Eastern and Western cores diverged at each point in time.

[8.2] *Units of measurement and abbreviations*

1 calorie = amount of heat energy needed to raise the temperate of 1 cm^3 of water by 1° C
1 calorie = 4.2 joules
1 joule = 0.238 calories
1 British Thermal Unit = 1,055 joules
1 ton wheat equivalent = 3,300,000 kilocalories
1 ton oil equivalent = 10,038,000 kilocalories
1 liter of wheat = 0.78 kilograms = 2,574 kilocalories
1 megajoule = 239,999 kilocalories
1 watt = 1 joule per second
1 horsepower = 750 watts
Basic adult physiological food requirement = c. 2,000-2,700 kilocalories per capita per day (= 8-11 megajoules = approx. 90 watts)
(http://www.livius.org/w/weights/weights4.html provides a convenient summary of ancient weights and measures)

BTU	British Thermal Unit
bya	billion years ago
C	centigrade
cal	calorie
cap	capita
cm	centimeter
GJ	gigajoule (1 billion joules)
hp	horsepower
J	joule
kcal	kilocalorie (1,000 calories)
kya	thousand years ago
MJ	megajoule (1 billion joules)
mya	million years ago
toe	tons oil equivalent

twe tons wheat equivalent
W watt
yr year

[8.3] *The nature of the evidence*

Reliable statistics on energy capture go back only part way into the 20th century in the Eastern core and to the early 19th century in the West, and even these data generally omit the large quantities of biomass used for fuel and construction in peasant households (Smil 1983, 1994). Patchier statistics go back to the 19th century in parts of China and Japan and to at least the 17th century in Western Europe. Before then there are textual records and occasional quantitative documents from both regions, stretching back to 1200 BCE in China and 3000 BCE in Mesopotamia and Egypt, but these cannot yield anything like the detail available for modern periods.

The further we go back in time, the more we must rely on archaeological and comparative evidence. The former sometimes give us quite a clear picture of the crops grown and technologies used, and a vaguer but still important sense of levels of trade and standards of living. In combination with comparative evidence for the energy yields of similar crops, technologies, trade, and lifestyles in well documented modern contexts, we can get at least some idea of energy capture, and we can occasionally cross-check the results against entirely independent classes of evidence, such as records of pollution from ice cores and peat bogs.

Combining such diverse data is of course a challenge and calls for constant guesswork. On the one hand, this makes that it unlikely that experts will ever agree precisely on scores before 1900 CE in the East and 1700 CE in the West; but on the other hand, the evidence does establish parameters for energy capture in the past that no expert would question. No one, for instance, would suggest that energy capture in the cores of the West (roughly Iraq-Egypt) or East (the Yellow River) in 1000 CE was as high as it would be in the United States or Japan a thousand years later, or, for that matter, as high as it would be in the cores in 1900, 1800, or even 1700 CE. Similarly few experts would argue that Western energy capture in 1000 CE was as high as it had been under the Roman Empire a thousand years earlier, but almost all would agree that it was higher than during the Mediterranean "dark age" around 1000 BCE. In the East, most Chinese economic historians would probably agree that Eastern capture was higher under the Song dynasty in 1000 CE than it had been under the Han in 1 CE, and much higher than under the Western Zhou a millennium before that. Any conclusions that violate these expectations will call for close scrutiny.

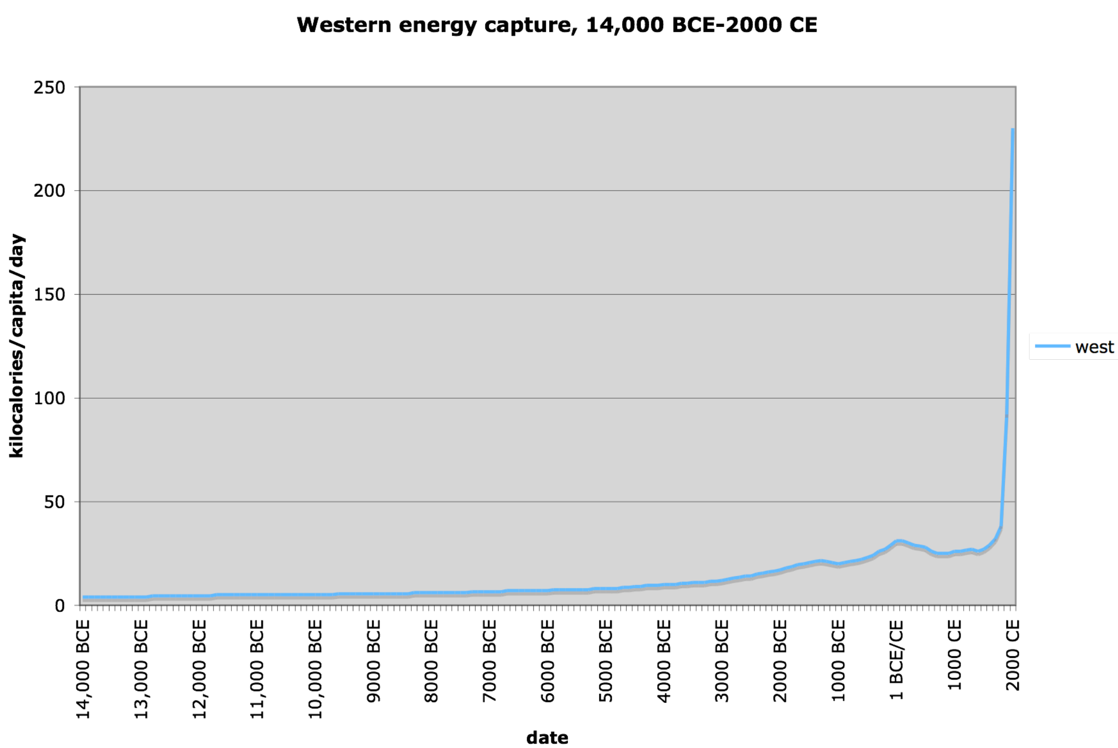
Table 2: Western energy capture, 14,000 BCE-2000 CE

14,000 BCE:	4,000 kcal/cap/day = 4.36 points
13,000 BCE:	4,000 kcal/cap/day = 4.36 points
12,000 BCE:	4,500 kcal/cap/day = 4.90 points
11,000 BCE:	5,000 kcal/cap/day = 5.45 points
10,000 BCE:	5,000 kcal/cap/day = 5.45 points
9000 BCE:	5,500 kcal/cap/day = 5.99 points
8000 BCE:	6,000 kcal/cap/day = 6.54 points
7000 BCE:	6,500 kcal/cap/day = 7.08 points
6000 BCE:	7,000 kcal/cap/day = 7.63 points
5000 BCE:	8,000 kcal/cap/day = 8.72 points
4000 BCE:	10,000 kcal/cap/day = 10.90 points
3500 BCE:	11,000 kcal/cap/day = 11.99 points
3000 BCE:	12,000 kcal/cap/day = 13.08 points
2500 BCE:	14,000 kcal/cap/day = 15.26 points
2250 BCE:	16,000 kcal/cap/day = 17.44 points
2000 BCE:	17,000 kcal/cap/day = 18.52 points
1750 BCE:	19,000 kcal/cap/day = 20.65 points
1500 BCE:	20,500 kcal/cap/day = 22.34 points
1400 BCE:	21,000 kcal/cap/day = 22.88 points
1300 BCE:	21,500 kcal/cap/day = 23.43 points
1200 BCE:	21,000 kcal/cap/day = 22.88 points
1100 BCE:	20,500 kcal/cap/day = 22.34 points
1000 BCE:	20,000 kcal/cap/day = 21.79 points
900 BCE:	20,500 kcal/cap/day = 22.34 points
800 BCE:	21,000 kcal/cap/day = 22.88 points
700 BCE:	21,500 kcal/cap/day = 23.43 points
600 BCE:	22,000 kcal/cap/day = 23.97 points
500 BCE:	23,000 kcal/cap/day = 25.06 points
400 BCE:	24,000 kcal/cap/day = 26.15 points
300 BCE:	26,000 kcal/cap/day = 28.33 points
200 BCE:	27,000 kcal/cap/day = 29.42 points
100 BCE:	29,000 kcal/cap/day = 31.06 points
1 BCE/CE:	31,000 kcal/cap/day = 33.78 points
100 CE:	31,000 kcal/cap/day = 33.78 points
200 CE:	30,000 kcal/cap/day = 32.69 points
300 CE:	29,000 kcal/cap/day = 31.60 points
400 CE:	28,500 kcal/cap/day = 31.06 points
500 CE:	28,000 kcal/cap/day = 30.51 points
600 CE:	26,000 kcal/cap/day = 28.33 points
700 CE:	25,000 kcal/cap/day = 27.24 points
800 CE:	25,000 kcal/cap/day = 27.24 points
900 CE:	25,000 kcal/cap/day = 27.24 points

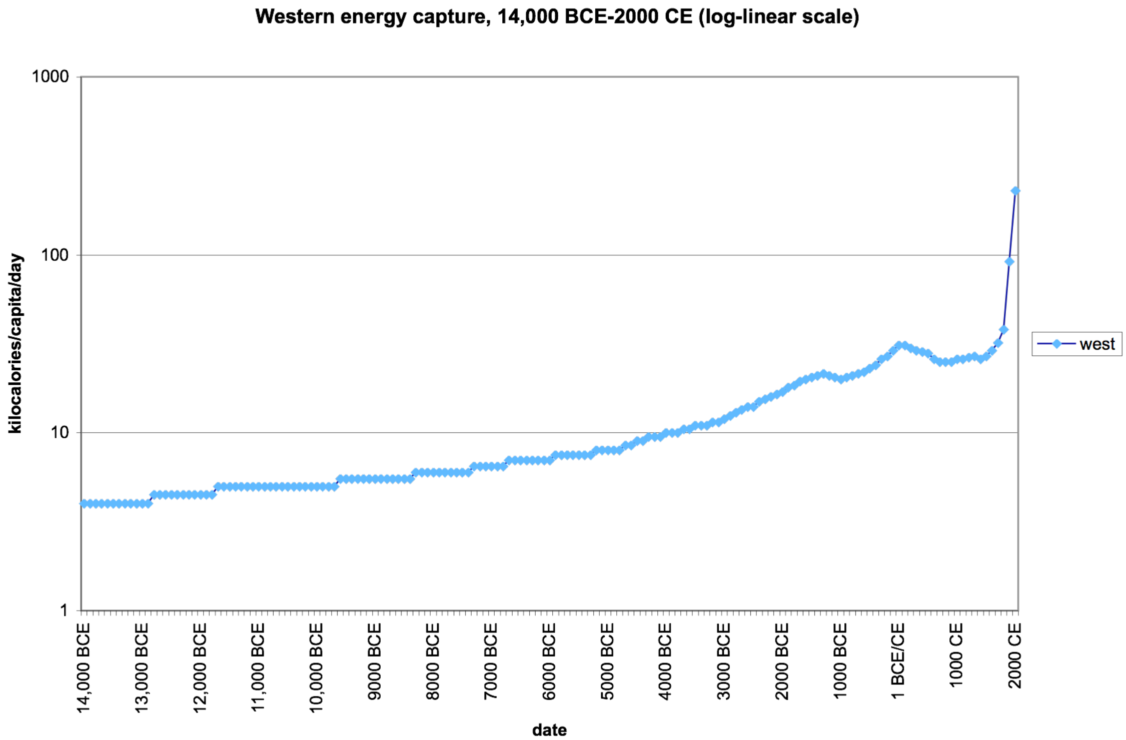
1000 CE:	26,000 kcal/cap/day = 28.33 points
1100 CE:	26,000 kcal/cap/day = 28.33 points
1200 CE:	26,500 kcal/cap/day = 28.88 points
1300 CE:	27,000 kcal/cap/day = 29.42 points
1400 CE:	26,000 kcal/cap/day = 28.33 points
1500 CE:	27,000 kcal/cap/day = 29.42 points
1600 CE:	29,000 kcal/cap/day = 31.06 points
1700 CE:	32,000 kcal/cap/day = 34.87 points
1800 CE:	38,000 kcal/cap/day = 41.41 points
1900 CE:	92,000 kcal/cap/day = 100.25 points
2000 CE:	230,000 kcal/cap/day = 250.00 points

Within certain limits we can certainly establish rough, ballpark figures for energy consumption; the important question is whether we can constrain the margins of error sufficiently to produce estimates that allow us to tell whether the best explanation for why the West rules is a long-term lock-in theory, a short-term accident theory, or some other kind of theory altogether.

[8.4] *Estimates of Western energy capture*



Graph 4. Western energy capture, 14,000 BCE-2000 CE, seen on a linear-linear scale



Graph 5. Western energy capture, 14,000 BCE-2000 CE, seen on a log-linear scale

Table 2, Graph 4, and Graph 5 show my estimates for Western energy capture since 14,000 BCE.

The best way to calculate energy capture in different periods is to proceed from the best to the least well known, so rather than starting in 14,000 BCE and moving continuously forward until 2000 CE I will start in the present and work back to 1700 CE, then make two jumps backward, before filling in the gaps between the three periods. The first jump is back to the classical Mediterranean world of roughly 500 BCE–200 CE, for which several economic historians have recently generated figures for consumption levels, and the second is back to the beginning of our story around 14,000 BCE, at which point (surprising as it may sound to non-archaeologists) we can make fairly confident estimates about late Ice Age hunter-gatherer consumption.

[8.4.1] *The recent past, 1700-2000 CE*

High-quality statistics are available for 2000 CE, putting total food + non-food per capita energy capture in the Western core (the United States) at about 230,000 kcal/cap/day (Food and Agriculture Organization 2006; United Nations Organization 2006). We also have good data for at least some aspects of the most advanced Western economies (around the northern shores of the Atlantic) in 1900 and even 1800. There are relatively rich data on industrial output in some parts of Europe going back to 1700 (e.g., Bairoch 1982; Crafts 1985), but the major challenge is how to combine this information with the use of biomass for fuel, housing, clothing, etc. The peasants who relied most heavily on biomass tended not to leave extensive textual records, which forces us to turn to estimates based on comparative evidence, cross-checked against qualitative evidence from literature and art. The qualitative evidence is often very rich (e.g., Thompson 1963: 207-488 on England between 1780 and 1832), but the need to bring these different sources together inevitably increases margins of error.

Combining figures for fossil and biomass fuels (e.g., Smil 1991, 1994: 12, 119, Fig. 5.15) and population data from Maddison (2003) suggests that typical energy capture in the Western core was somewhere around 92,000 kcal/cap/day in 1900 and 38,000 kcal/cap/day in 1800. By my rough estimate, the 92,000 kcal/cap/day in 1900 can be broken down into about 41,000 from fossil fuels, 8,000 as food/animal feed, and 43,000 from non-food biomass, and the 38,000 kcal/cap/day in 1800 can be broken down into about 7,000 from fossil fuel, 6,000 as food/animal feed, and 25,000 from non-food biomass. The figures of 92,000 kcal/cap/day in 1900 and 38,000 kcal/cap/day in 1800 neatly bracket Cook's estimate of 77,000 kcal/cap/day for advanced Western economies in 1860, and seem consistent with the evidence of probate records and industrial archaeology for the increase in household goods (e.g., Hudson 1979; Mrozowski 2006; Shackel 2009). The figures for 1800 and 1900 involve wider margins of error than the figure for 2000, but are consistent with the impressionistic historical literature on energy use and with Allen's (2001, 2007, 2009b) reconstructions of trends in real wages.

My estimate of a 242 percent increase in per capita energy capture in the western core between 1800 and 1900 is smaller than the well established statistics for the growth of industrial output in the developed Euroamerican core (e.g., Christian 2004: Table 13.1, identifying a 1,023 percent increase, which, corrected for population growth from Christian's Table 11.1, produces a 402 percent increase in per capita industrial output across the 19th century). That is because estimates of industrial output normally leave biomass and muscle power out of the calculus completely, producing a misleading picture of overall energy capture. A significant slice of the 19th century's industrial output went toward replacing biomass and muscle, rather than simply adding to them, in the process allowing much higher population densities in the industrial core without producing environmental catastrophe.

When we look back before 1800 CE the uncertainties of course multiply, but strong constraints continue to apply to our estimates. Western energy capture clearly grew more slowly in the 18th century than it would do in the 19th, but faster than it had done in the 17th or 16th; and if Cook was correct that the advanced agriculturalists of the late Middle Ages were already capturing 26,000 kcal/cap/day, early modern northwest Europeans around 1700 CE must have been consuming somewhere between 30,000 and 35,000 kcal/cap/day. I base this guess of a roughly 5:4 ratio between energy capture in the Western core in 1700 and 1400 CE on the plentiful textual and archaeological evidence across the entire social spectrum for the improvement in the quality of housing (Deetz 1996, Dyer 1989: 109-210), the increasing quality and variety of household goods (Brewer and Porter 1993), rising real wages in northwest Europe (Allen 2001, 2009b), rising consumption of expensive calories (Cavaciocchi 1997; Barrett et al. 2004; Muldner and Richards 2005, 2007; Salamon et al. 2008), and the longer hours being worked (de Vries 2009). Angus Maddison (2003) estimated that western European GDP/cap increased from $798 (expressed in Geary-Khamis dollars, a hypothetical unit with the same purchasing power as $1 US in 1990) to $1,032 between 1500 and 1700. Nearly all the gains, however, were in non-food calories; adult stature, a robust indicator of levels of childhood nutrition (Haines and Steckel 2000; Steckel and Rose 2002), was much the same in 1700 as in 1400 CE (Koepke and Baten 2005 and http://www.uni-tuebingen.de/uni/wwl/twomillennia.html; Clark 2007: 55-62).

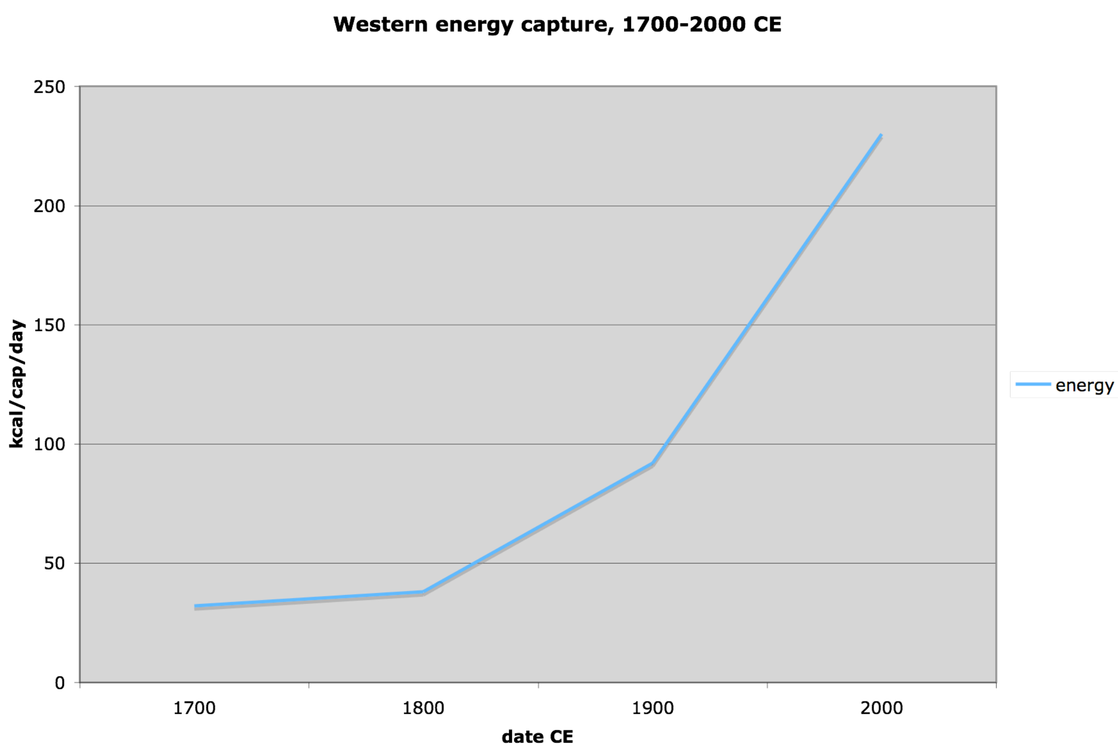
My figure of 32,000 kcal/cap/day for 1700 CE is necessarily a guess, but is probably less than 10 percent wide of the mark, because:

1. If northwest European consumption was already above 35,000 kcal/cap/day in 1700 CE but only rose to 38,000 in 1800, it is hard to explain where all the extra energy being consumed in industry and transport was coming from (as Allen [2001] has shown, real wages probably declined between 1750 and 1800 and then grew only slowly until 1830, thanks to massive profit-taking and reinvestment by the new economic elites).

2. If, on the other hand, northwest European consumption remained below 30,000 kcal/cap/day in 1700 despite already having reached 26,000 by 1400, it would be hard to explain how trade, industry, agriculture, and forestry could have expanded as vigorously as we know they did across the 15th, 16th, and 17th centuries while energy capture grew so slowly.

3. If we make room for Western consumption to have been below 30,000 kcal/cap/day in 1700 despite having risen sharply since 1400 by pushing the figure for 1400 down from 26,000 toward 20,000 kcal/cap/day, we would have to argue either (a) that the (by premodern societies) quite productive European societies of around 1400 were no more successful at energy capture than those of the southwest Mediterranean Bronze Age some 3,000 years earlier, which seems unlikely, or (b) that energy capture around 1600 BCE was lower still, perhaps somewhere around 15,000 kcal/cap/day; which, in turn, would require us to depress earlier figures still further. Since we can fix a floor of at least 4,000 kcal/cap/day under post-Ice Age energy capture, pushing 2nd-millennium BCE energy levels down to 15,000 kcal/cap/day makes it hard to explain the enormous differences in living standards between the substantial homes at sites like Ur around 1500 BCE (Wooley and Mallowan 1976; generally, Postgate 1994a) and the very simple ones at sites like 'Ain Mallaha in Israel around 12,000 BCE (Valla et al. 1999; generally, Bar-Yosef and Valla 1991).

Graph 6 shows my estimates for modern times.



Graph 6. Western energy capture, 1700-2000 CE

[8.4.2] *Classical antiquity (500 BCE–200 CE)*

In the last few years several historians and economists have tried to quantify real wages and GDP/cap in the classical Mediterranean. These are not the same thing as total energy capture, but the calculations are a very helpful step forward.

(a) Real wages

We have spotty but useful information on both wages and the prices of food in the ancient Mediterranean, and for a handful of times and places we can calculate how much wheat certain categories of people could afford to buy each day. In an important recent paper, Walter Scheidel (2010a) has followed the example of early modern historian Jan van Zanden (1999) in converting ancient wage data into a "wheat wage," representing the number of liters of wheat a worker could buy with one day's income. Armed with that information and the fact that a liter of wheat (0.78 kg) contains 2,574 kcal of energy, we can calculate the energy capture represented by wage levels. Scheidel shows that shortly before 400 BCE the real wages of an adult Athenian man bought more than 22,400 kcal/day, and by the 320s BCE they had risen to somewhere between 33,500 and 40,000 kcal/day.

These are extremely high figures, coming close to those for the 18th- or even early 19th-century Western core. Scheidel's figures for Roman Italy in the first few centuries CE vary much more, with wages in the city of Rome ranging from the equivalent of 15,500 kcal/day to more than 43,000 kcal/day, and those from Pompeii ranging from 12,000 kcal/day through 30,000 kcal/day. The average of these data points is about 25,000 kcal/day, but—as Scheidel points out—it is hard to put much confidence in the number.

There are two main drawbacks to the real-wage approach to energy capture. First, the data points are so scattered that we rarely know how typical they are. There is only one case in ancient western Eurasia, in Babylon between 385 and 61 BCE, where we have a really detailed series of price points for a range of commodities, and here prices fluctuated wildly (van der Spek 2008). When we only have single price points separated by centuries of silence we could easily be misunderstanding our sparse information.

Second, it seems impossible to say exactly how the wage levels relate to total food + non-food energy capture. We only have wage information for a few professions, and most people probably worked outside the monetized economy, spending their lives in family farms or firms. In classical Athens, the wage data are dominated by state employment such as military pay and pay for holding public offices (Loomis 1998); with the state acting as a monopsonist, it is hard to say how pay levels relate to the private sector. Roman data are not so badly skewed (see especially Drexhage 1991 and Rathbone 1996, 1997, 2009, focused on Egypt), but they too have their problems. We do not know how the undocumented professions compared to documented ones; what sources of income families normally had to supplement the wages that are mentioned in our texts; and how much of the typical family's energy capture came from biomass that lay completely outside the monetized economy.

(b) GDP/cap

Table 3 Estimates of Roman GDP/capita

	Kg wheat equivalent/ cap/yr	kcal/ cap/yr	kcal/ cap/day
Hopkins (1980)	491	1,620,000	4,438
Goldsmith (1984), Maddison (2007)	843	2,780,000	7,616 Italy only: 12,712
Temin (2006)	614	2,030,000	5,561
Goldsmith (1984), Maddison (2007), as adjusted by Scheidel and Friesen (2009)	620	2,050,000	5,616 Italy only: 9,370
Egypt "bare bones," Scheidel and Friesen (2009)	390	1,290,000	3,534
Egypt "respectable," Scheidel and Friesen (2009)	940	3,100,000	8,493
Scheidel and Friesen (2009)	714	2,360,000	10,710
Diocletian's Price Edict, 301 CE, After Allen (2009a)	204	670,000	1,836

A second approach is to calculate an ancient society's GDP and divide this by the size of its population, and several historians and economists have provided estimates for the Roman Empire in the first two centuries CE (Table 3). This approach avoids some of the problems of real wages, but adds new challenges of its own, most obviously that the calculations depend on a string of assumptions. Scheidel and Friesen (2009: 4) go so far as to concede that "Students of the Roman world who are unfamiliar with our approach might be tempted to dismiss this project as a tangled web of conjecture."

The most important assumptions are estimates of minimum food needs, a "step-up" to represent non-food consumption, and another to represent government spending. Opinions differ on all these numbers, with the results that estimates of GDP/cap in the 1st-2nd century CE range from an equivalent of 7,364 kcal/cap/workday (Hopkins 1980, 2002, 2009) to 12,636 kcal/cap/workday (Goldsmith 1984, Maddison 2007: 11-68). Scheidel and Friesen (2009) themselves stress the need to operate with a range of estimates, but do offer 10,710 kcal/cap/workday as a summary figure (total output of 50 million twe/70 million people/220 workdays). Combining the estimation approach with data from Roman Egypt, they suggest the actual figure must lie between 5,864 and 14,091 kcal/cap/workday; and that several different approaches all converge on this same range.

These energy capture scores are considerably lower than those derived from real wages. There appear to be two reasons for this. First, the GDP/cap estimates apply to the whole Roman Empire, rather than the core region in Italy. This raises what in *Why the West Rules—For Now* (Morris 2010: 39-42) I called the "Pomeranz Problem": as historian Kenneth Pomeranz has stressed (2000: 3-10), lumping together a small, highly developed region (like 18th-century England) with a large, unevenly developed region (like 18th-century China) distorts comparisons. We need to focus on the most developed core within the West, in this case Italy. Maddison (2007) has recognized this, suggesting that tax and tribute flows into Italy raised its NDI/cap two-thirds higher than that of the rest of the empire, which would push Maddison's estimate of Italian energy consumption to 12,712 kcal/cap/workday (or, following the adjustments that Scheidel and Friesen [2009] suggest to his scores, 9,370 kcal/cap/workday).

This Italian score, however, is still lower than even the bottom end of the range of energy capture implied by Scheidel's (2010) real wages from Rome and Pompeii, and close to Cook's (1971) calculation for early agriculturalists (by which he meant southwest Asian farmers around 5000 BCE). The explanation for this is that the "step up" used in all the proposed GDP figures seriously underestimates the quantities of biomass for fuel and construction, wind and waterpower, and raw materials in the Roman economy. Hopkins (1980) allowed for just a 33 percent step up to cover seed and wastage, and even the highest estimate, by Goldsmith (1984, shared by Maddison 2007 and Scheidel and Friesen 2009), is only 75 percent.

Comparative data on energy capture suggest that the true level was much higher.

Table 4. Energy densities

A1.4 Energy Densities of Foodstuffs and Fuels

Foodstuffs and Fuels		*Energy Densities (MJ/kg)*
Foodstuffs		
Very low	Vegetables, fruits	0.8–2.5
Low	Tubers, milk	2.5–5.0
Medium	Meats	5.0–12.0
High	Cereal and legume grains	12.0–15.0
Very high	Oils, animal fats	25.0–35.0
Fuels		
Very low	Peats, green wood, grasses	5.0–10.0
Low	Crop residues, air-dried wood	12.0–15.0
Medium	Bituminous coals	18.0–25.0
High	Charcoal, anthracites	28.0–32.0
Very high	Crude oils	40.0–44.0

Source: Derived from Smil (1991).

In his masterly studies of biomass energy, Vaclav Smil (1991, 1994) divides biomass fuels into two categories by energy density (Table 4). His "very low density" class (peats, green wood, grasses), yielding 5-10 MJ/kg (= 1,200-2,400 kcal/kg), and "low density" class (crop residues, air-dried wood), yielding 12-15 MJ/kg (= 2,880-3,600 kcal/kg) seem most relevant to ancient Rome, where coal use was always marginal. We of course have no statistics on biomass fuel use in the Roman Empire, but we do have some suggestive comparative statistics. Tropical 20th-century CE hunter-gatherer groups often got by with less than 500 kg/cap/yr of biomass fuel, mostly presumably of very low-density type, representing perhaps something like 1,300-2,600 kcal/cap/day. Farming societies in colder climates often used as much as 2.5 tons/cap/yr, presumably mixing the low and very low categories; a 50/50 low/very low mix would generate 12,329-22,191 kcal/cap/day. The advanced organic economies of 18th-century northwest Europe and North America used 3-6 tons/cap/yr. If we again assume a 50/50 split between low- and very low-density fuels, that would be something like 21,699-43,397 kcal/cap/day (Smil 1994: 119). These data are consistent with Cook's non-food estimate of 20,000 kcal/cap/day for advanced agriculturalists in late medieval western Europe. The most important question to answer is where the economies of the ancient Mediterranean fit within this range, and for that we must turn to archaeology.

(c) Archaeological evidence

The archaeological approach involves starting from the actual material remains left by ancient attempts to capture energy, in the form of human and animal bones, carbonized seeds, pollen and chemical traces of pollution, houses, and artifacts. This ground-up approach is messier than the more stylized real-wage and GDP/cap approaches, but it is also more empirical (Ober 2010 shows how the archaeological, real-wage, and GDP/cap approaches can be made to work together for ancient Greece).

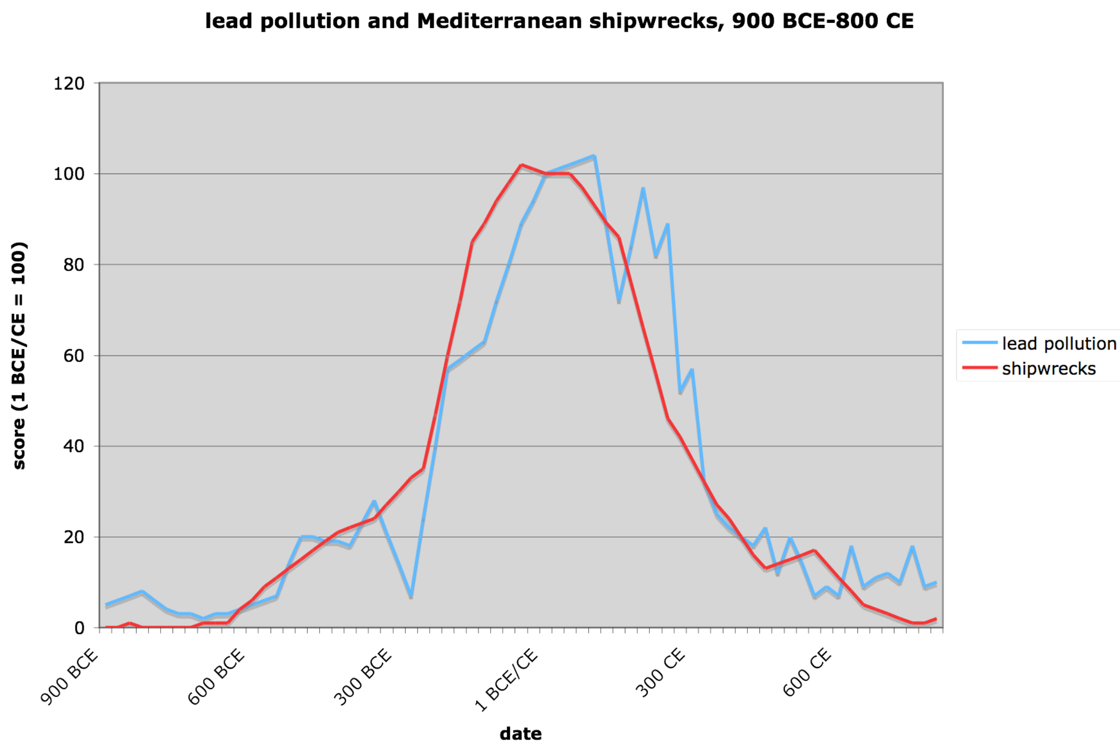
The archaeological evidence confirms the impression of the real wage numbers that 4th-century BCE Greeks enjoyed high energy capture by premodern standards (Morris 2004, 2005, 2007). Their diet was relatively good, with a generally rather low but meat content (though with significant vaiations from site to site: Legouilloux 2000) but quite high contributions from olives, wine, and fish (e.g., Coulson and Vaughan 2000; Prieto and Carter 2003; Keeleyside et al. 2009; Vika et al. 2009; Lytle 2010), as well as fruit and garlic (Kusan 2000; Megaloudi et al. 2007). It was not enough to push average adult male stature much above 168 cm (Morris 2004; Kron 2005), but typical Greek intake of food calories must have been relatively high by premodern Mediterranean standards, perhaps reaching 4,000-5,000 kcal/cap/day.

Since the 1980s survey archaeologists have realized that older models of Greek agriculture, seeing it as inefficient and risk-averse, simply could not be correct, because an agricultural system of this kind could not have generated enough food to support the population densities of the Greek world (on which see now Hansen 2006, 2008). The evidence of settlement patterns and excavated farmsteads in fact indicates a shift between 500 and 200 BCE toward intensively worked blocks of contiguous land making heavy use of manure and often producing for the market, obtaining yields from dry-grain farming that would not be matched again until at least the 19th century (Hodkinson 1988; Cherry et al. 1991; Jameson et al. 1994; Snodgrass 1994' Bintliff et al. 2008). Pollen data support this, with peaks for cereal and olive production in the period c. 500-200 BCE not only in Greece (e.g., Zangger et al. 1997) but all across the east Mediterranean (Eastwood et al. 2006) and as far into Asia as western Iran (Djamali et al. 2009).

Classical Greek houses were large and comfortable, typically having 240-320 m^2 of roofed space. The evidence for house prices is disputed (Hoepfner and Schwandner 1994: 150; Nevett 2000), but an average house probably cost 1,500-3,000 drachmas at a time when a 5,000-kcal daily diet cost about half a drachma—meaning that an average house represented 15-30 million kcal. Amortized out over a 30-year lifespan, that represented close to 1,375-2,750 kcal/day. (There is no way to know what Greek expectations about the lifetime of a house were, but 30 years seems roughly consistent with the rate of rebuilding on archaeological sites.)

It is harder to quantify the per capita energy consumption represented by the kilns, furnaces, workshops, etc., behind the artifacts we find in Greek houses, or by the temples, fortifications, arms and armor, warships, public buildings, private monuments, roads, harbors, artworks, and countless other categories of objects archaeologists have recovered, or by the transport costs of bringing much of the food Greeks ate from farms as far away as Ukraine and Egypt. However, comparing the quality of housing and sheer abundance of artifacts on classical Greek settlements (e.g., Olynthus, destroyed in 348 BCE and published in great detail in Robinson et al. 1929-52, with a valuable summary in Cahill 2002) with those in medieval or early modern northern European settlements in northern Europe (e.g., Beresford and Hurst 1991, on Wharram Percy in England) and, *a fortiori*, those in medieval and early modern Greece (e.g., Cooper 2002, Sigalos 2004, Vionis 2006, Vroom 1998) gives a good sense of the high material standard of life enjoyed by classical Greeks.

It is also striking that classical Greece supported not just relatively high levels of non-food consumption but also high population densities around the Aegean Sea in the 4th century BCE (Hansen 2006). In several parts of Greece, the 4th century BCE saw densities that would not be equaled until the twentieth century CE, and the simple fact that so many Greeks lived in towns or small cities, rather than hamlets or farms (Hansen 2006, 2008), must mean that their energy capture reached unusual heights. In an important paper, Geof Kron (forthcoming; cf. Clark 2002) has shown from the housing evidence that in many respects, the typical Greek lived better than the typical 18th-century Briton. Ancient Greeks seem to have grown to about the same height (about 168 cm for men and 158 cm for women) as early-modern west Europeans (Morris 2004, Kron 2005). The Greek archaeological data point clearly toward high (by premodern standards) energy capture; I suggest a figure somewhere between 20,000 and 25,000 kcal/cap/day in the 4th century BCE (and most likely closer to the upper than to the lower figure), having risen sharply from a "Dark Age" level closer to 16,000 kcal/cap/day between 1000 and 800 BCE (Morris 2007).



Graph 7. Economic growth and collapse in the 1st millennia BCE and CE, as documented by shipwrecks and lead pollution

The copious Roman evidence suggests that energy capture in 1st-2nd century CE Italy was even higher than that in 4th-century BCE Greece. The evidence for agricultural yields remains debated (see Hopkins 2002), although output in irrigated Egyptian agriculture seems to have been extremely high by premodern standards (Bowman 2009; Bagnall 2009). Quantitative studies of consumption—including everything from animal bones in settlements (A. King 1999; Ikeguchi 2007; Jongman 2007a) to numbers of shipwrecks (A. Parker 1992; cf. Wilson 2009a; Fulford 2009), levels of lead pollution (de Callataÿ 2005; Kylander et al. 2005; Vleeschouwer et al. 2007; Renson et al. 2008; Mighall et al. 2009), frequencies of public inscriptions on stone (MacMullen 1982; Jongman 2009), numbers of coins in circulation (Duncan-Jones 1994, Lo Cascio 1997), and quantities of archaeological finds along the German frontier (Holstein 1980: 137; Schmidt and Gruhle 2003)—also point the same way: per capita energy capture in the Mediterranean world increased strongly during the first millennium BCE, peaked somewhere between 100 BCE and 200 CE, then fell again in the mid-first millennium CE (Graph 7). Further evidence should become available with the publication of Robyn Veal's detailed study of charcoal evidence for the wood economy of the city of Pompeii between the 3rd century BCE and 79 CE (Veal, forthcoming; I would like to thank Graham Claytor for this information.)

Each category of material has its own difficulties (see Bowman and Wilson 2009, Scheidel 2009a), but no single argument can explain away the striking increase in evidence for non-food consumption across the 1st millennium BCE and the peak in the first two centuries CE. The shipwreck data and the vast garbage dumps of transport pottery surrounding the city of Rome (a single one of which, at Monte Testaccio [http://ceipac.gh.ub.es/MOSTRA/u_expo.htm], contains the remains of 25 million pots, used to ship 200 million gallons of olive oil) also attest to the use of non-food energy to increase food supply. Some scholars also identify an increase in stature in the 1st-2nd century CE (e.g., Jongman 2007a, 2009; Kron 2005), although others (e.g., Giannecchini and Moggi-Cecchi 2008; Scheidel 2010b, 2010c) are more pessimistic, suggesting that adult male Romans in early imperial Italy were typically under 165 cm tall, and were actually shorter than Iron Age or medieval Italians. More evidence—and more consistent application of statistical techniques—should resolve the question, and we must look forward to the appearance of Geertje Klein-Goldewijk's database of Roman skeletons.

As in Greece, the housing evidence (Barton 1996; Ellis 2000) may be the most informative, and Robert Stephan (in prep.) and Geof Kron are now collecting and analyzing this material. Data from Egypt (Alston 2001) and Italy (Wallace-Hadrill 1994) already suggest that by the first centuries CE typical Roman houses were even bigger than classical Greek houses had been, and that sophisticated (by premodern standards) plumbing, drainage, roofs, and foundations spread far down the social ladder.

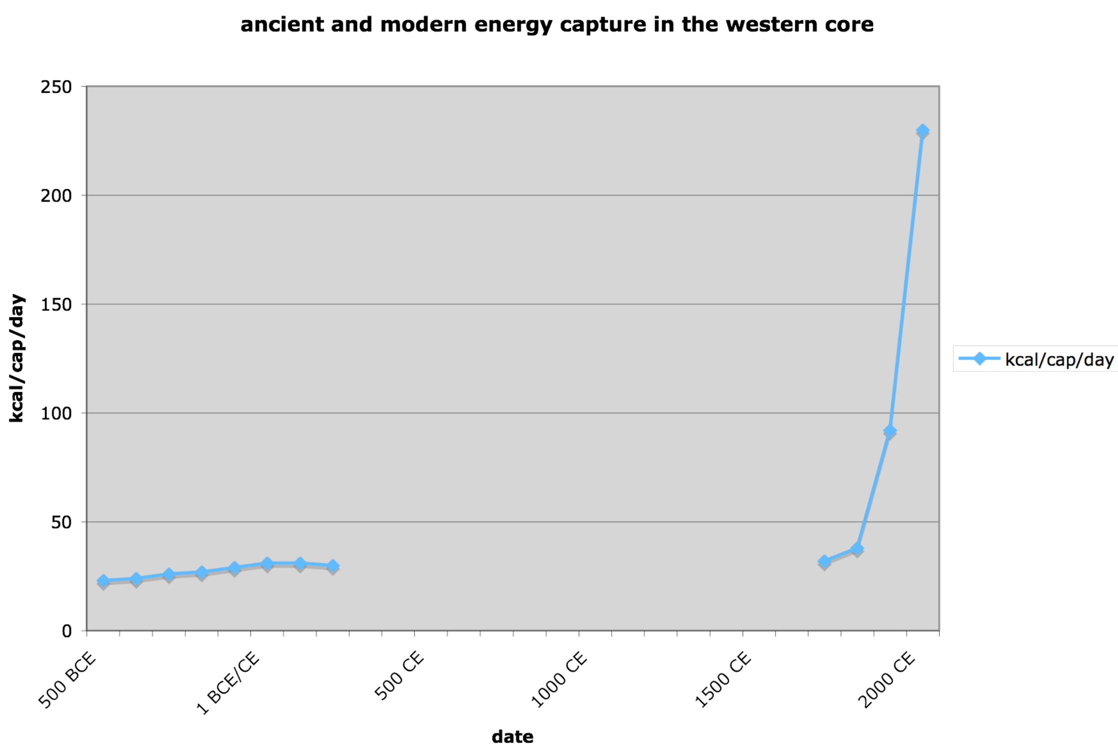
The explosion of material goods on Roman sites is even more striking. Mass production of wheel-made, well-fired pottery, amphoras for wine and olive oil, and base-metal ornaments and tools reached unprecedented levels in the first few centuries CE (on amphoras, Paterson 1982; Peacock and Williams 1986; Tchernia 1986; Panella and Tchernia 1994; Peña 2007; on iron tools, S. Harvey 2010). Similarly, distribution maps show that by 200 CE trade networks were larger and denser than they would be again until at least the 17th century (Bang 2009), stretching all the way to India (Tomber 2008).

The archaeological data suggest that the real-wage and particularly the GDP/cap approaches to the Roman economy seriously underestimate energy use in the Roman core. All the GDP/cap calculations to date have begun with human physiological requirements for food calories and added an arbitrary "step up" for non-food consumption, taking neither the comparative evidence for biomass energy nor the archaeological evidence for the extraordinary surge in non-food consumption into consideration. The largest step up that has been proposed has been 75 percent (Goldsmith 1984; Maddison 2007; Scheidel and Friesen 2009), but the comparative evidence suggests that this is far too low for a complex agrarian economy. Cook (1971) concluded that even in a "normal" advanced agricultural economy the step up should be well over 300 percent, and the archaeological evidence makes it clear that Roman Italy between about 200 BCE and 200 CE was anything but a "normal" advanced agricultural economy. There is no way at present to be very precise about the step up, but the archaeological evidence suggests that it was considerably larger than in classical Greece. I suspect that it was more like 400 percent, suggesting total energy capture of about 31,000 kcal/cap/day in the Roman core by the 1st century CE.

This estimate puts energy capture in the Roman core around 100 CE just slightly behind that in the northwest European core in 1700 CE. This is a slightly more optimistic assessment of the Roman economy than the GDP/cap estimates imply. Maddison's figures suggest that the Roman Empire in the first few centuries CE compares best with northwest Europe around 1500 CE, although he then goes on to point out that Roman urbanization levels match better with west European levels around 1700 CE (Maddison 2007: 37). Similarly, while Scheidel and Friesen (2009) conclude that the empire-wide Roman economy in the 2nd century CE lacked the sophistication of the Dutch around 1580-1600 CE or the English around 1680-1700, they do note that performance may have been better in the Italian core.

So far as I know, the only other attempt to calculate total Roman energy capture in the terms I am using here has been Vaclav Smil's comments in his book *Why America is Not a New Rome* (2010: 107-113). The book aims to highlight the differences between the contemporary USA and ancient Rome, one of which, Smil quite rightly emphasizes, is an enormous gap in energy capture. However, in demonstrating this very valid point, he offers what seem to me implausibly low estimates of Roman energy use. He suggests that contemporary American energy use is thirty to fifty times higher than Roman, which would set Roman total energy capture somewhere between 4,600 and 7,700 kcal/cap/day; if we assume that roughly 2,000 kcal/cap/day of this was food (which means ignoring the archaeological evidence for relatively high levels of expensive calories from meat, oil, and wine), that leaves just 2,600-5,700 kcal/cap/day to cover all other energy consumption. To justify this estimate, Smil suggests that Roman fuel use was just 180-200 kg of wood equivalent per capita per year, or roughly 1,750-2,000 kcal/cap/day.

These numbers seem impossible to reconcile either with the archaeological evidence for Roman consumption, the levels of Roman-era lead pollution in bogs, ice cores, and lake beds, or with Smil's own data on premodern biomass use in his book *Energy in World History* (Smil 1994: Table A1.4). Smil's estimates for Rome would group its energy capture with some of the simplest agricultural societies on record; whereas my estimates place peak Roman energy capture (c. 100 CE) alongside northwest Europe's in 1700 CE, and Maddison's and Scheidel and Friesen's place it closer to 16th-century northwest Europe's, Smil's estimate of Roman non-food energy capture in *Why America is Not a New Rome* (2,600-5,700 kcal/cap/day) is just one-eighth of his own estimate for 18th-century northwest European energy capture (21,700-43,400 kcal/cap/day) in *Energy in World History*. The other classes of evidence make this seem much too low.



Graph 8. Estimated Western energy capture, 500 BCE-200 CE and 1700-2000 CE

(d) Conclusion

Per capita energy capture increased across the 1st millennium BCE, peaking somewhere around 30,000 kcal/cap/day in the 1st century CE. By premodern standards this was an extremely high level, close to that of the Western core around 1700 CE, although it probably never reached even 15 percent of contemporary American levels. Graph 8 shows my estimates for the ancient (500 BCE-200 CE) and modern (1700-2000 CE) periods.

[8.4.3] *Between ancient and modern (200–1700 CE)*

The next challenge is to bridge the long gap between ancient Mediterranean and early modern European data. I divide the 1,500-year period into three phases: (a) 200-700, (b) 700-1300, and (c) 1300-1700.

[8.4.3.1] *200-700 CE*

Graph 7 on p. 46 above indicates a dramatic, centuries-long decline in industrial and commercial activity and the consumption of meat in this first phase, suggesting that energy capture also fell. In principle, a famous edict on prices and wages set up by the Roman emperor Diocletian in 301 CE ought to provide a starting point by allowing us to reconstruct real wages, but in practice there are difficulties. Scheidel (2010a) calculated that the real wage for unskilled workers implied by the Edict was just 9,376 kcal/cap/day, down from roughly 25,000 kcal/day (but with a very wide variance of ±12,000 kcal/day) in 1st-2nd century CE Italy; Robert Allen's calculations (2009), however, suggest a real wage worth just 1,439 kcal/cap/day, as low as the most depressed levels in 18th-century Europe, which would be hard to sustain for any length of time even if 100 percent of the wages were spent on food. The Edict certainly seems to suggest that real wages fell between 150 and 301 CE, but Scheidel and Friesen (2009: 10 n. 29) are probably right to suggest that its idealized figures diverged significantly from real-world prices.

Several recent surveys of the archaeological evidence (McCormick 2001; Ward-Perkins 2005; Wickham 2005) reinforce the impression of falling energy capture between 200 and 700 CE, although they also show that the details and pace of change varied wildly from region to region. Some new forms of energy capture, such as moldboard plows and watermills, became commoner after 200, especially on the Roman core's backward northern fringe; but the general trend ran strongly in the other direction. Until specialists in late Roman archaeology quantify the evidence more precisely, it will be difficult to make accurate estimates; but between 200 and 700 the general picture is of large houses of stone and brick being replaced by smaller structures of wood and clay; paved streets being replaced by mud paths; sewers and aqueducts stopping working; life expectancy, stature, and population size falling, and the surviving people moving from cities to villages; long-distance trade declining; plain, handmade pottery replacing slipped, wheelmade wares; wood and bone tools being used more often, and metal ones less; factories going out of business and village craftsmen or household producers taking their places.

I suggest in *Why the West Rules—For Now* (Morris 2010: 292-308) that energy capture began declining in the Western core in the 160s CE when population movements across the steppes merged microbes from previously distinct Eastern and Western Eurasian disease pools. Graph 7 (p. 46 above) suggests that the disruptions set off by this so-called Antonine Plague (Scheidel 2002, 2010b; for a different view, see, Bagnall 2002) had already begun driving energy capture down before 200 CE. The 3rd century certainly saw decline, especially in the western parts of the Roman Empire, but a second wave of collapse beginning in the 5th century was much more profound. As early as 450 CE a steep decline in material wellbeing can be seen in Britain in the far northwest; by 500 it is also clear in Gaul; by 600, in Italy and Spain; and by 700 it had engulfed North Africa and the Byzantine heartland around the Aegean. As this wave of collapse rolled from Northwest to Southeast between 400 and 700, the Western core contracted geographically, and although there still was a core at the end of this phase (concentrated in Egypt, Syria, and Iraq), its smaller scale corresponded to lower per capita levels of energy capture.

The decline between 200 and 700 was not catastrophic. Irrigation systems, cities, and rudimentary states remained intact in Egypt and Iraq, and the Arab conquests may have stimulated increases in agricultural productivity (Bagnall 1993; Watson 1982). Elsewhere, even in the darkest days (such as the 6th century in Italy or the 7th in Anatolia) people went on gathering wood, cooking dinner, and doing most of the same things that they had done in the heyday of the Roman Empire. However, their overall energy capture definitely declined. In the present state of the evidence, we can only bandy around impressionistic guesses based on the pictures created by specific excavation reports; I estimate that energy capture perhaps fell about 10 percent between 200 and 500 CE (from about 31,000 kcal/cap/day in the core to about 28,000 kcal/cap/day) and then a further 10 percent, to about 25,000 kcal/cap/day, between 500 and 700. Most likely, Egyptian and Iraqi per capita energy levels only fell slightly between 200 and 700 (see Bagnall 1993), but the collapse of Italy, North Africa, and southern Gaul resulted in energy capture in the West's most developed core area being 20 percent lower in 700 than it had been in 200 CE.

This is a much less dramatic collapse than Graph 7 would seem to indicate (the reason being that Graph 6 reflects chiefly those non-food kilocalories that changed most), but it might still surprise some Roman historians. Through the 19th and much of the 20th century, historians tended to agree that Gibbon had got the main outlines of the story of late antiquity correct, but in the 1960s critics reacted against this view. According to the most important revisionist, Peter Brown, "It is too easy to write about the Late Antique world [of 200-700] as if it were merely a melancholy tale of 'Decline and Fall'." However, Brown observed, "we are increasingly aware of the astounding new beginnings associated with this period … we have become extremely sensitive to the 'contemporary' quality of … so much that a sensitive European has come to regard as most 'modern' and valuable in his own culture" (Brown 1971: 7).

Brown's goal was to remind historians not to allow the decline-and-fall narrative to obscure the complex and fascinating reality of late antique cultural change, but after three decades of reminders, many historians have now gone to the other extreme. "There is now a widespread conviction," Andrea Giardina has observed, "that … concepts such as 'decline' or 'decadence' are ideologically charged and consequently misleading" (Giardina 2007: 746). Brown was quite right that we should see the period 200-700 as the time of the transformation of classical into early medieval culture, but too many historians have allowed this new perspective to blind them to the fact that this was also an era of political and economic collapse. The strategist Edward Luttwak has recently observed (2009: 1) that "the newly fashionable vision of an almost peaceful immigration and a gradual transformation into a benign late antiquity is contradicted by the detailed evidence of violence, destruction, and the catastrophic loss of material amenities and educational attainments that would not be recovered for a thousand years, if then." I find little to disagree with in this conclusion (see particularly Ward-Perkins 2005; Halsall 2007; Jongman 2007b).

The best antidote is simply to compare site reports and survey data for virtually any part of the Roman Empire in the 2nd century CE with those for the same region in the 7th century CE (e.g., in Britain, Colchester [Hawkes and Hull 1947; Hawkes and Crummy 1995; Crummy 1981, 1984], Wroxeter [White and Barker 1998; Barker et al. 1997], St. Albans [Neal et al. 1990], or London [Grimes 1968]; in Italy [survey in Christie 2006], Rome [Steinby 1993-2000; Coates-Stephens 1996], Naples [Arthur 2002], or San Giovanni di Ruoti [Freed 1985]; in Egypt, Coptos [Herbert and Berlin 2003] or Bakchias [Bitelli et al. 2003]). Every site (even in Egypt, which weathered the storm better than any other part of the Roman Empire) reveals falling material standards of living and energy capture.

[8.4.3.2] *700-1300 CE*

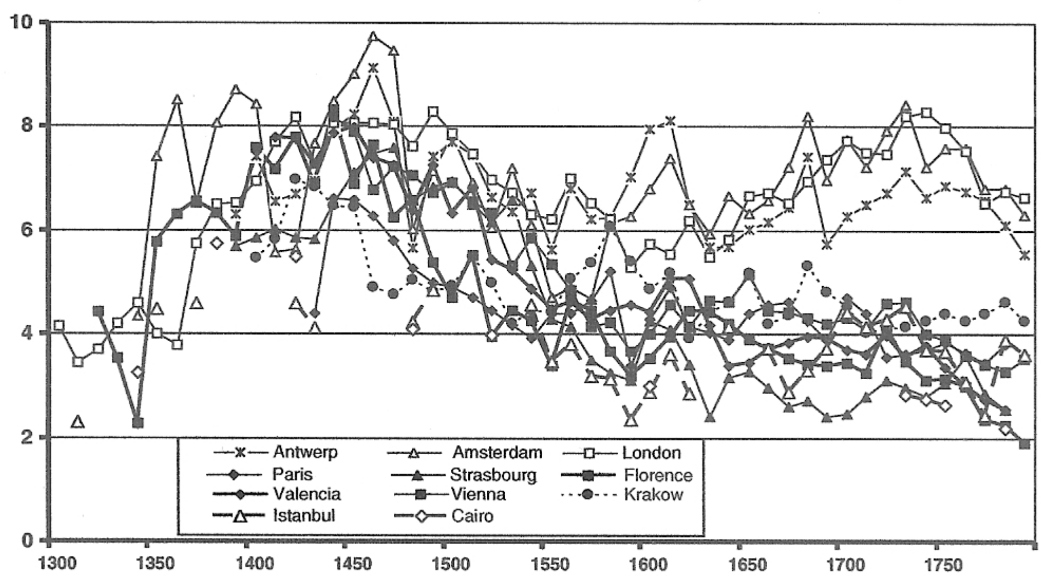
While there can be little doubt that there was a general slow upward trend in energy capture in the Western core across these 600 years, the details are difficult to document, largely because historians and archaeologists of the medieval Muslim world have paid less attention to energy capture as those of classical antiquity (see Insoll 1999; Milwright 2010).

By 700 the Western core had contracted to the Egypt-Syria-Iraq region. There is some evidence that energy capture was falling in Syria by the 8th or 9th century and in Iraq by the 9th or 10th century (Wickham 2005), and across the whole of southwest Asia by the time of the 11th-century Seljuk invasions, but it seems to have remained high in Egypt throughout the period 700-1300 and to have risen in Spain. Christian Europe definitely saw a vigorous economic revival after 900, and by 1300 the richest area, Italy, was catching up with the Islamic core in Egypt.

The Byzantine Empire also saw rapid economic recovery in the 10th century (Harvey 1989; Laiou 2002), and in a valuable recent paper, Branko Milanovic (2006) has used the relatively rich sources to calculate that the real wage of average unskilled workers in the Byzantine heartland around 1000 was around $680 per year (PPP in 1990 Geary-Khanis International Dollars). Like the Roman GDP/cap calculations, this figure considers little except food calories, and Milanovic (2006: 454) allows a particularly small "step up" for non-food income. He does, however, observe that the figure he reaches for Byzantine GDP/cap is roughly 20 percent lower than most estimates for GDP/cap in the Early Roman Empire and 20-25 percent higher than Jan Luiten van Zanden's calculation (cited in Milanovic 2006: 460) for English incomes in 1086 and Gregory Clark's (2005: 1308) for English builders in the early 13th century. All these GDP/cap studies use similar methods, suggesting that even if the absolute numbers understate levels of energy capture in the past, the relative shifts over time may accurately reflect the realities.

Extrapolating from these comparisons by making a bigger "step up" for non-food calories, I suggest that if energy capture in the 1st-century CE Roman core was about 31,000 kcal/cap/day, in Byzantium around 1000 CE it was about 26,000 kcal/cap/day; and if Milanovic (2006: 450) is correct in following Robert Lopez's suggestion (1951: 215) that Byzantine and Abbasid energy levels were rather similar around 1000 CE, the score for the Western core as a whole should also be 26,000 kcal/cap/day, with energy capture on the distant periphery in early 2nd millennium England around 21,000 kcal/cap/day. If anything, the comparison between Roman and Byzantine GDP/cap and real wages might slightly underestimate the overall decline in energy capture between 100 and 1000 CE, because the decline probably affected non-food calories much more than food calories, and the Goldsmith/Maddison/Milanovic estimates largely ignore these non-food calories.

If this chain of inferences is justified, we must conclude that energy capture in the Western core increased only very slightly, from 25,000 to 26,000 kcal/cap/day, between 700 and 1000 CE. The weakness of the archaeological evidence makes it difficult to test this, although the numbers certainly seem consistent with finds from Greece (Lock and Sanders 1996; Sigalos 2004; Bintliff and Stöger 2009; Schepartz et al. 2009). I suggest that energy capture in the core remained fairly flat at about 25,000 kcal/cap/day between 700 and 900, and then started rising in the 10th century, to 26,000 kcal/cap/day in 1000 and perhaps 27,000 kcal/cap/day by 1300. The archaeological evidence from Europe (e.g., Graham-Campbell and Valor 2006; Grenville 1999; O'Keefe 2008; Woolgar et al. 2009) seems consistent with this, with clear signs of increasing household inventories, more substantial homes, more trade, and much more state spending. It is also consistent with the assumption that Italy was the richest part of Europe.



Graph 9. Real wages of unskilled workers, 1300-1800 CE (after Pamuk 2007: Figure 2)

The impossibility of making direct archaeological comparisons between 13th-century Italy and Egypt is frustrating, but the real wage data collected by Sevket Pamuk (2007: Figure 2) suggest that by 1300 wages (and presumably energy capture as a whole) in northern Italy were probably catching up with those in Egypt and were ahead of those in Byzantium; and by 1400 Italy had pulled ahead of Egypt too (Graph 9).

[8.4.3.3] *1300-1700 CE*

If my estimates for energy capture the Middle Ages and modern times are roughly correct, then the period 1300-1700 must have seen an increase of roughly 23 percent in the Western core, from about 26,000 kcal/cap/day to about 32,000 kcal/cap/day. This would be faster than in any other period of the same length except for 400-1 BCE, which saw a 29 percent increase (24,000 kcal/cap/day to 31,000 kcal/cap/day). The similarities between the rates of increase and overall scores in ancient and early modern times suggests that fondness of historians for drawing analogies between these periods may not be misplaced.

Quite detailed series of real wages are now available for many European cities since the later Middle Ages (e.g., Allen 2001; Clark 2005; Pamuk 2007). These suggest a general decline in wages for unskilled labor across the 13th and early 14th centuries followed by a great surge after 1350, when the Black Death increased land: labor ratios. As population grew in the later 15th and 16th centuries real wages generally fell, but by 1600 a gap was opening between wages in northwest Europe, which were trending back up, and those in southern and eastern Europe, which continued to decline. By 1700 real wages for the unskilled in Amsterdam were 30 percent higher than they had been in 1350 and those in London were 80 percent higher. Both these increases are larger than those for energy capture mentioned in the previous paragraph.

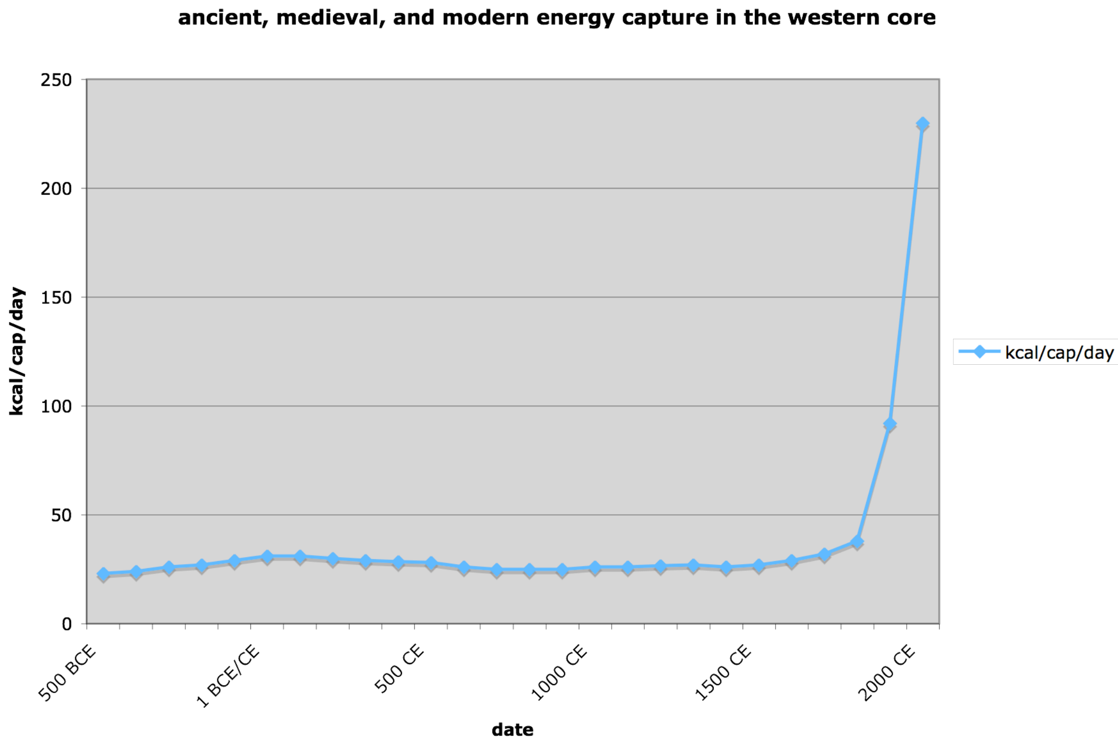
Angus Maddison's estimates of GDP/cap (2007) give a rather different picture for the period 1500-1700. Maddison calculated that productivity continued to increase everywhere in western Europe except Italy across the 16th century; as he saw it, Holland and Britain took the lead by 1700 not because their growth revived in the 17th century while other regions went backward but because they grew even faster than other European economies. He identified a 29 percent increase in western European productivity between 1500 and 1700.

The difference between these pictures of real wages and GDP/cap, like those between these measures in ancient times, is largely to be explained by the fact that they are measuring rather different things (Angeles 2008). The inability of western European lords to reassert their authority after the Black Death (Aston and Philpin 1985) caused a major shift in resources toward the poor, driving real wages up much faster than productivity; and as population rose in the 16th century, power shifted back toward the aristocracy and real wages declined even though GDP/cap continued to rise.

The century-long surge in real wages after 1350 also obscures the evidence for a broader 14th-century depression (Thrupp 1972; Kedar 1976; Mazzaoui 1981; Miskimin 1969), afflicting many dimensions of trade and industry. Research in the 1990s (summarized in Hunt and Murray 1999) showed that this was not as severe as some earlier historians had believed, but the calamities and uncertainties of the 14th century nonetheless do seem to have driven energy capture down. I suggest a small decline from 27,000 kcal/cap/day in 1300 to 26,000 in 1400, but in the absence of quantified archaeological evidence form settlements this can only be a guess.

The archaeological evidence for rising energy capture between 1300 and 1700 is very clear, and seems consistent with the 23 percent increase suggested above, although it is not detailed enough to allow a test of my suggestion that levels fell 1,000 kcal/cap/day during the 14th century. The evidence for rising agricultural yields in northwest Europe is strong (e.g., Slicher van Bath 1963; Clark 1987; Grigg 1992), as is textual and material documentation of the enormous increase in fishing catches (e.g., Barrett et al. 2004; Cavaciocchi 1997; Müldner and Richards 2005, 2007; Salamon et al. 2008). The increase in food calories was still not enough to affect adult stature noticeably (Koepke and Baten 2005), but in non-food calories the changes were more striking, especially after 1500 (Cipolla 1974). Details in wills and legal suits as well as excavated remains all suggest that in town and country alike, western Europeans had bigger, more sophisticated houses and a wider range of material goods in 1700 than they had had in 1300 (Braudel 1981; Cipolla 1993; Dyer 1989; Dyer and Jones 2010; Hoskins 1953; Johnson 1996; Smail, in prep.). Industrial production was rising (de Vries and van der Woude 1997; Blair and Ramsay 2003; Smith and Wolfe 1998), people were working longer hours (de Vries 2009), and fossil fuels such as peat and coal were beginning to contribute enormous amounts of energy (Hatcher 1993; Malanima 2000; Unger 1984). While precise comparisons necessarily remain speculative northwest European energy capture per capita probably overtook the Roman peak (c. 100 CE) during the 17th century.

Graph 10 shows the complete sequence of estimates from 500 BCE through 2000 CE.



Graph 10. Western energy capture, 500 BCE-2000 CE

[8.4.4] *Late Ice Age hunter-gatherers (c. 14,000 BCE)*
Surprising as it may at first seem, we are on sounder ground with estimates of energy capture at the end of the Ice Age than in any subsequent era till the 18th century. Although thousands of years have passed since farmers drove the last foragers out of the initial Western core in the Hilly Flanks, and altough the climate and ecology of the region have changed dramatically, comparative studies fix the parameters of possible energy capture fairly precisely.

The well established fields of bioenergetics and primate ecology (Kleiber 1961, Clutton-Brock 1989) provide a good picture of energy use among the great apes, our nearest evolutionary neighbors, and economic anthropologists have measured energy capture among contemporary foragers everywhere from hot African environments (e.g., Bailey 1991; Dwyer 1983; Lee 1979; Silberbauer 1981) to cold Siberian ones (e.g., Katzmaryk et al. 2005).

The earliest known species of *Homo* living in East Africa between 2.5 and 1.8 million years ago (mya) had energy needs similar to those of chimpanzees, but the evidence is fairly good that *Homo habilis* ate meat more often than chimpanzees do (Klein 2009: 262-71), and they may even have become active hunters rather than scavengers. It typically takes about 10 calories of chemical energy, photosynthesized by plants from solar energy, to produce 1 calorie of kinetic energy in an animal, so *Homo habilis* was already substituting expensive calories for cheap ones. Even so, with their small bodies and brains and simple material culture, *Homo habilis* probably only required on average something like 1,500 kcal/cap/day.

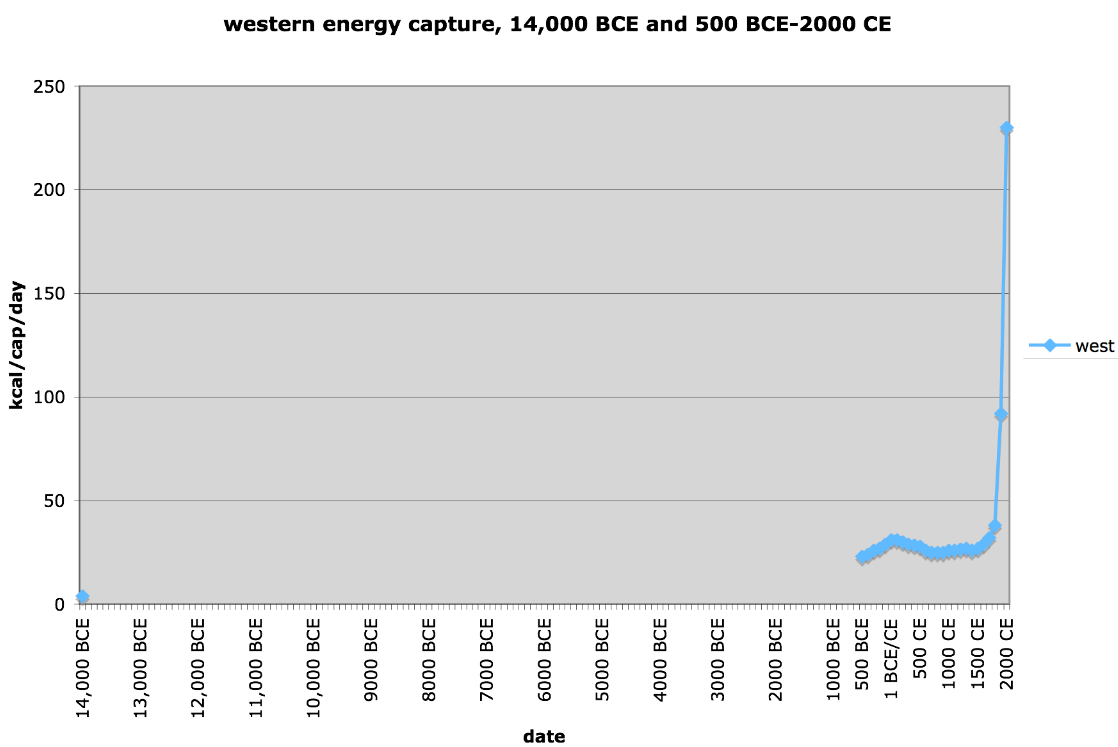
Energy capture probably increased significantly with the evolution of *Homo erectus/ergaster* in East Africa around 1.8 mya. Brain size increased by roughly 40 percent (from 610 to 870 cc), body weight by 75 percent (from 35 to 62 kg), and stature by nearly 50 percent (1.15-1.7 m) (Klein 2009: Table 4.10). *Homo erectus/ergaster* may have been able to make fire at will, greatly increasing their non-food energy capture and transforming their food in ways that allowed them to absorb more of its calories (Wrangham 2009). Because the archaeological record before about 50 thousand years ago (kya) is so flimsy, the evidence is disputed, but recent finds at Gesher Benot Ya'aqov in Israel strongly suggest that *Homo erectus/ergaster* had mastered fire by 790 kya (Goren-Inbar et al. 2004; Alperson-Afil 2008). If cooking food by releasing energy from wood had become a commonplace strategy, total energy capture among *Homo erectus/ergaster* may have risen as high as 2,000 kcal/cap/day.

As proto-humans moved north of the line 40° N, they would have been forced to increase energy capture to deal with the colder climate. There is good evidence for regular fire-making 400 kya at Beeches Pit in Britain and Schöningen in Germany (Gowlett 2006; Preece et al. 2006; Thieme 2005). Stable isotope analysis suggests that Neanderthals got a tremendous amount of their food energy in the form of expensive meat calories (Bocherens et al. 1999, 2001; Niven 2006; Richards et al. 2000, 2008; Richards and Schmitz 2009), and bioenergeticists have estimated that they typically consumed at least 3,000 and probably closer to 5,500 kcal/cap/day (Leonard and Robertson 1997; Sørenson and Leonard 2001; Sørenson 2009).

Modern humans in the late Ice Age needed rather fewer calories for food and therefore for fuel (Leonard and Robertson 1992), but other categories of non-food energy capture increased dramatically. Genetic analyses of lice suggest that humans started wearing fitted clothes at least 50 kya and possibly 150 kya (Kittler et al. 2003; Kitchen et al. 2010), and anatomical studies of fossil foot bones show that shoes were in regular use by at least 40 kya (Trinkaus and Hong 2008). *Homo sapiens* also began using small amounts of energy for personal decoration around 50 kya and much larger amounts for building shelters. Archaeologists have as yet found no convincing evidence for proto-humans building houses (Klein 2009: 543-49), but since at least 50 kya modern humans began investing energy in buildings. From the very earliest times, these buildings required the capture of thousands of kilocalories of non-food energy, but repaid the effort by trapping heat from fireplaces as well as providing shelter when caves were not available (Wilkins 2009).

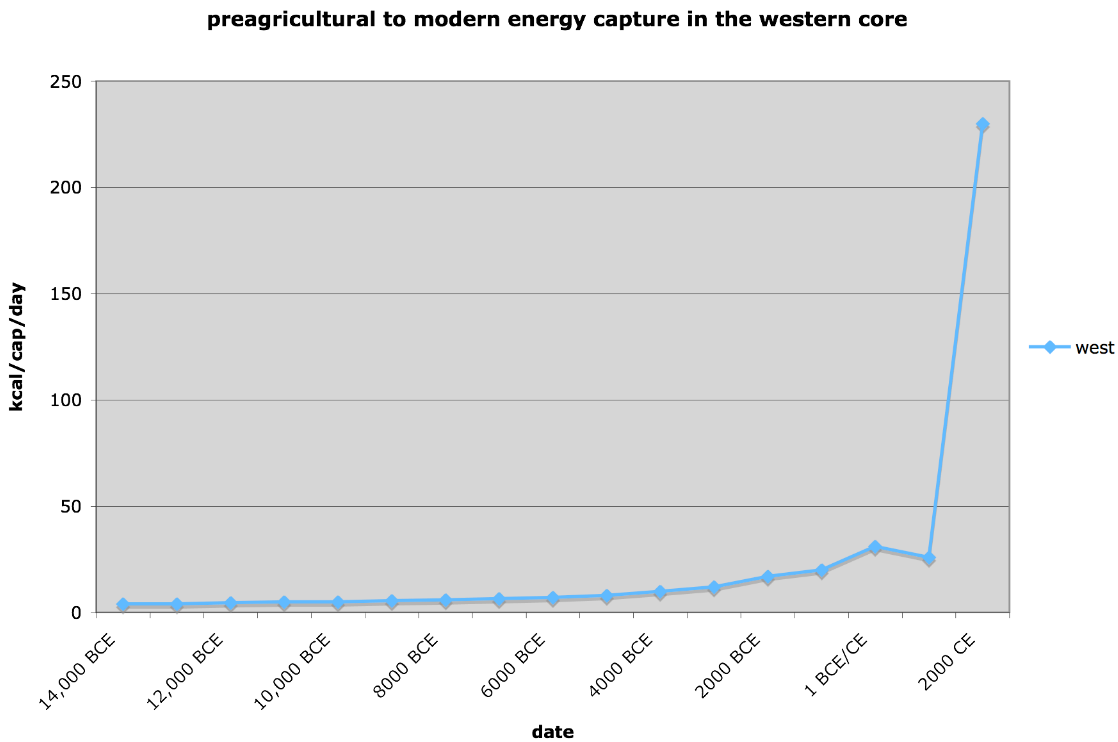
Toward the end of the Ice Age, around 14,000 BCE, total human energy capture (food + non-food) at sites like Ohalo (Nadel 1996) in the Western core in southwest Asia must have been around 4,000 kcal/cap/day. Food energy cannot have fallen much below 2,000 kcal/cap/day for long periods, while if non-food energy capture had fallen much below an additional 2,000 kcal/cap/day Natufian material culture would have been much poorer than the archaeological record shows it to have been, and if non-food energy capture had risen much above an additional 2,000 kcal/cap/day the archaeological record would be much richer than it in fact is.

[8.4.5] *From foragers to imperialists (14,000-500 BCE)*



Graph 11. Western energy capture: 14,000 BCE and 500 BCE-2000 CE

As Graph 11 makes clear, there is a very wide gap to fill between the reasonably secure estimate of energy capture for late Ice Age hunter-gatherers in the Western core (4,000 kcal/cap/day in 14,000 BCE to the next reasonably secure estimate, of 23,000 kcal/cap/day in the city-dwellers of the east Mediterranean in 500 BCE. We could simply assume a steady growth rate, either arithmetic or geometric, across these 13.6 millennia, but in fact the combination of the actual archaeological and textual data, comparanda from economic anthropology, and comparisons with the scores after 500 BCE allow us to be more precise (Graph 12).



Graph 12. Millennium-by-millennium estimates of Western energy capture, 14,000 BCE-2000 CE

I will divide the period into six phases, first briefly describing some of the developments in each phase in general terms and then trying to quantify what these changes meant for energy capture.

(a) Affluent foragers, 14,000-10,800 BCE

The archaeological evidence seems quite clear that as the weather became warmer and more stable at the end of the Ice Age in southwest Asia, diets grew richer, huts became bigger and more elaborate, and material culture expanded (see Bar-Yosef and Valla 1991 and Mithen 2003 for good surveys). Finds from Abu Hureyra in Syria even suggest that cultivation of rye had selected for bigger seeds by 11,000 BCE (Hillman et al. 2001). People in southwest Asia remained foragers (albeit increasingly sedentary ones), and in 11,000 BCE their energy capture remained much closer to the 4,000 kcal/cap/day of the late Ice Age than to the 12,000 kcal/cap/day that Cook (1971) ascribed to early agriculturalists, but we must assume a substantial increase in percentage terms (if not, by the standards of later times, in the absolute number of kilocalories) across these three millennia.

(b) The Younger Dryas mini-ice age, 10,800-9600 BCE

What the Younger Dryas meant for energy capture is debated (see Mithen 2003: 46-55; Barker 2006: 117-31). On the one hand, many permanent villages seem to have been abandoned by 10,000 BCE, their residents returning to more mobile strategies and investing less energy in construction and material culture; on the other, the first monuments appear at sites like Qermez Dere (Watkins 1990), Jerf al-Ahmar, and Mureybet (Akkermans and Schwartz 2003: 49-57), requiring an increase in energy capture. It seems to me that the safest procedure, at least until our evidence improves significantly, is to assume that energy capture remained basically flat between 10,800 and 9600 BCE. This involves a major departure from the steady arithmetic growth and the geometric growth models, both of which predict that energy capture increased by 17 percent between 10,800 and 9600 BCE (from 9,000 to 10,500 kcal/cap/day in the arithmetic model and from 6,000 to 7,000 kcal/cap/day in the geometric model).

(c) The agricultural and secondary products revolutions, 9600-3500 BCE

As the weather warmed up and settled down after 9600 BCE we see two contrasting trends. First, cultivation resumed relatively rapidly. Unnaturally large seeds of wheat and barley appear at multiple sites in the Jordan, Euphrates, and Tigris Valley by 9000 BCE and become normal by 8500 BCE, by which the first fully domesticated wheat and barley (with tough rachis and hulls that do not shatter) is seen at a handful of sites. By 8000 about half the carbonized cereal seeds from the Hilly Flanks are domesticated; by 7500, virtually all are (Fuller 2007; Colledge et al. 2004; Colledge and Connolly 2007).

Domestication raised energy capture per hectare under cultivation, and in the short run, at least, raised energy capture per capita too. However, one of the main uses of excess energy was produce more babies, which set off the second trend. Villages were caught in Malthusian traps: geometric population growth outpaced arithmetic growth in the food supply, driving per capita food supply back down toward bare subsistence. Together, the two trends generated the paradoxical result that while non-food energy capture clearly rose substantially between 9600 and 3500 BCE, overall food supply was at best stagnant. Cheap domesticated cereal calories increasingly replacing more varied diets based on hunted and gathered wild foods, and the skeletal record suggests that on the whole early farming populations were less healthy than pre-agricultural hunter-gatherer groups (Larsen 1995, 2006; Armelagos and Harper 2005).

Excavations across the last thirty years have also revealed that the rate of change in energy capture after the Younger Dryas was much slower than was previously thought (see, e.g., Barker 2006; Fuller 2007; Cohen 2009; B. Boyd 2010). Rather than a single "agricultural revolution," we should probably think of a drawn-out transition from full-time foraging, through a combination of foraging and cultivation, to the gradual replacement of most wild and cultivated food by domesticated plants and animals. The most recent studies suggest that this took about 2,000 years, from roughly 9600 through 7500 BCE, in the Hilly Flanks.

Further, this was only the first stage; the shift toward domesticated plants and animals was followed by the even longer "secondary products revolution" (Sherratt 1997: 155-248) in food energy, in which farmers gradually intensified practices and discovered new applications of domesticated plants and animals. It took many centuries for people to learn to alternate cereals with beans to replenish the soil; to process cereals more effectively, removing impurities; to bake bread effectively; to harness animals for milk and/or traction rather than eating them all while still young; or to build efficient plows and wheeled carts. Storage facilities increased in sophistication (Garfinkel et al. 2009), and wells provided water for places streams did not reach (Garfinkel et al. 2006). The "full package" of ancient dry-grain agriculture in southwest Asia was not in place till at least 4000 BCE. By then weeding, rotating, and manuring crops were all standard practice, significantly increasing energy capture per hectare (see Araus et al. 2001, 2003; Bogaard et al. 2007), even if most or all of the energy surplus was converted into extra people rather than into higher food-energy capture per capita.

The increase in non-food energy capture was just as slow but is much more visible. As when trying to calculate energy capture in the post-Roman period, the best method is simply to compare settlement sites of different dates. A famous photograph from Abu Hureyra (Figure 1) illustrates the point nicely: at the top is part of a small but sturdy house built around 8000 BCE, and below are the remains of much flimsier huts dating back to 12,000 BCE (Moore et al. 2000). If we continue moving through time, we find more substantial houses still by 6500 BCE (with Çatalhöyük providing the best-known examples [Hodder 2006]), and by 4500 BCE the Ubaid phase houses of Mesopotamia were still more impressive (Pollock 1999: 78-148). Michael

Roaf (1989) describes a fairly typical but particularly well-preserved example, covering 170 m^2, from Tell Madhhur in Iraq. By that time houses were solidly built from mudbricks, usually organized around a shady courtyard, with waterproof roofs, a well, and large storage facilities.

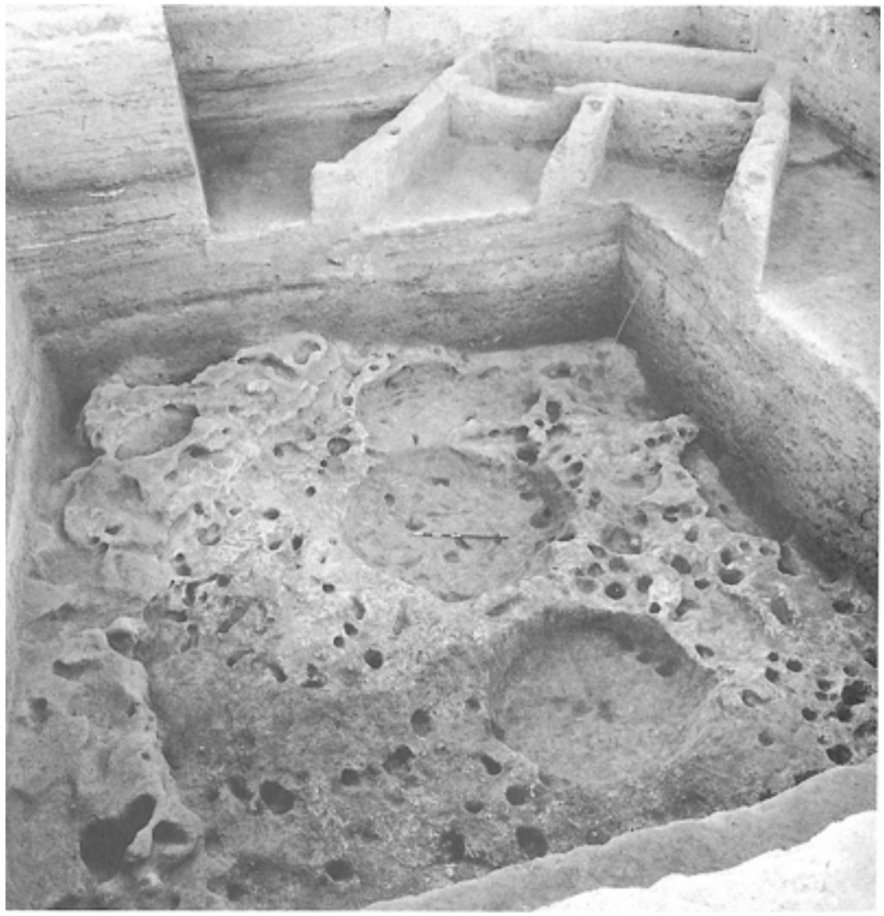


Figure 1. House remains from Abu Hureyra, Syria. At the bottom are postholes from huts of around 12,000 BCE; at the top, remains of a mudbrick house, c. 8000 BCE (after Moore et al. 2000)

Household goods increased similarly. Pottery came into use around 7000 BCE, with specialist producers using the potter's wheels soon after that. Weaving seems to have steadily increased in sophistication, and copper ornaments, tools, and weapons came into use by 3500 BCE. So far as I know no archaeologist has systematically quantified household goods from southwest Asia over time, but the contrast between the contents of the houses from Abu Hureyra (c. 12,000 and 8000 BCE) and Tell Madhhur (c. 4500 BCE) are striking.

The energy consumed on public monuments of various types also increased sharply. Jericho had some kind of fortification tower as early as

9000 BCE (although the evidence is contested; see Bar-Yosef 1986 and McClellan 2006), but this pales in comparison with the elaborate temple at Eridu (Safar et al. 1981) or the platform at Susa (Stève and Gasche 1971) by 3500 BCE. Figure 2, a reconstruction drawing of the sequence of temples at Eridu from 5000 through 3500 BCE, makes the point about increasing non-food energy capture as effectively as the photograph of the Abu Hureyra houses.

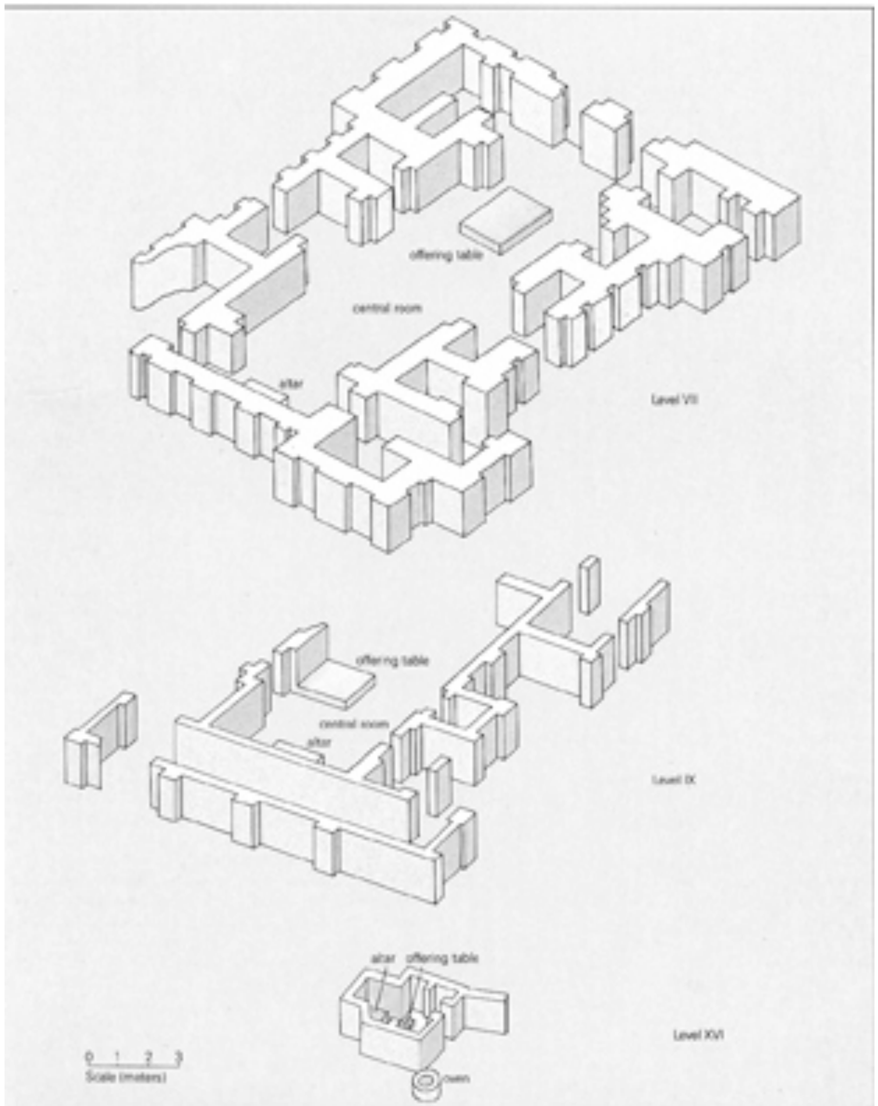


Figure 2. Temple remains from Eridu, Iraq. At the bottom is the temple built around 5000 BCE; at the top, the version built around 3000 BCE (after Roaf 1990)

Energy captured for transport also increased. The first unambiguous evidence for linking animal power to wheeled vehicles is Sumerian representations of ox-drawn carts from around 4000 BCE, and by 3000

BCE actual carts were being included in tombs (Littauer and Crouwel 1981; Piggott 1983). Wind- and waterpower were also harnessed; canoes were being used for fishing by 5000 BCE, and models from Eridu show that proper boats were in use by 4000.

The increase in non-food energy capture between 9600 and 3500 BCE is very clear (Maisels 1990; Nissen 1988; Pollock 1999; Postgate 1994a; and Roaf 1990 provide excellent surveys of different parts of the period). As in the case of the affluent foragers of 14,000-11,000 BCE, though, we should remember that while the increase in energy capture between 9600 and 3500 must have been very large in percentage terms, in terms of absolute kilocalories it was nevertheless small by modern standards. Even at the end of this long period, people in the Western core were still villagers, their energy capture somewhere around Cook's (1971) "early agriculturalists" stage in Graph 3 (p. 29 above).

(d) Archaic states, 3500-1200 BCE

The rate of increase in energy capture accelerated after 3500 BCE with the development and spread of states in the Western core. Once again the lack of a systematic collection of data on skeletal stature hampers discussion, as does the scarcity of stable isotopic and other anthropological analyses of paleodiet, but the general impression created by the scattered data is that there was relatively little overall change in food calorie intake. We can sketch very generalized pictures of diet and nutrition in different parts of the Western core (e.g., MacDonald 2008; Yokell 2004), but more detailed studies reveal enormous local variation (e.g., Coulson and Vaughan 2000 and Triandaphyllou et al. 2008 for the Aegean). There probably was a long-term trend toward higher yield: seed ratios across the third and second millennia (reaching perhaps 30:1 in irrigated Mesopotamian barley farming by 2000 BCE [Jursa 2010: Table 1]), but population seems to have increased just as quickly, consuming the gains.

As in earlier periods, however, we also see a large increase in per capita capture of non-food calories. The most striking aspect is the spread of metal use, which gives the period its standard name, the Bronze Age. Royal bureaucratic records document enormous bronze foundries at palaces, and excavators have found plenty of examples of private foundries (e.g., Postgate 1994a: 226-29). Stone tools largely disappeared from the Western core by 1200 BCE.

The famous pyramids, ziggurats, palaces, and temples of the Bronze Age of course consumed massive amounts of energy (Feinman and Marcus 1998); the Great Pyramid at Giza (c. 2600 BCE) is still the world's heaviest building, weighing around 1 million tons. The scale of long-distance trade also increased sharply, especially after 1600 BCE (e.g., Cline 1994; Parkinson and Galaty 2010), and is vividly illustrated by shipwrecks found off the coast of Turkey (Bass 2010; Pulak 2010). Most important of all, though, is the increase in energy consumed by the much larger populations of the 3rd and 2nd millennia BCE. In every part of the core, standards of housing and the quantity and craftsmanship of household goods rose between 3500 and 1200 BCE (there are many surveys of Bronze Age archaeology, but the following have particularly good accounts and references to site reports—Egypt: Kemp 1989; Mesopotamia: Postgate 1994a: 73-108, 191-240; Syria: Akkermans and Schwartz 2003: 211-359; Aegean: Dickinson 1994: 95-207; Elam: Potts 1999: 85-257).

As in other periods, there is strong regional variation as well as local episodes of collapse. In the Aegean, for instance, the Neopalatial period (c. 1800-1600 BCE) on Crete was a time of apparent wealth, with very large houses (median size of floor plan 130 m^2; McEnroe 1982) and rich material culture. After 1600 BCE, however, non-food wealth seems to have declined on Crete, while continuing to increase in mainland Greece.

The biggest episodes of collapse in this period seem to have been in Mesopotamia after 3100 BCE, when Uruk was burned and its large material culture zone broke up, and across the whole area from Mesopotamia through Syria and the Levant to Egypt (and with echoes across much of the Mediterranean) between 2200 and 2000 BCE. However, while both these episodes left clear archaeological traces, it is less obvious that they had much impact on energy capture.

There seem to be several reasons for this. A large part of the explanation is that both collapses were in fact very spotty, with some sites destroyed and abandoned while others flourished (e.g., in Syria after 2200 BCE, Tell Leilan and Sweyhat were abandoned around 2200, while Tell Brak and Mozan grew even larger). Archaeologists disagree over the underlying causes (see Dalfes et al. 1997; Moeller 2006; van de Mieroop 2010: 86-96), and some even debate whether "collapse" is an appropriate term (e.g., Cooper 2006; Porter 2011).

A second factor is the emergence of a new core area in Egypt by 3100 BCE. The Nile Valley was unaffected by the 3100 BCE collapse, and while the disasters after 2200 did have a major impact on Egypt, they did so on a different schedule than in Mesopotamia. By 2100 Egypt's Old Kingdom and Mesopotamia's Akkadian Empire had both unraveled, but the strong new Ur III state had reunited much of Mesopotamia. By 2000 Ur had also collapsed, but the Middle Kingdom had reunited Egypt. Despite the obvious traumas of the 2200-2000 BCE period, energy capture seems to keep growing in the western core. The same is true of the upheavals of 1800-1550 BCE.

Finally, the way I have measured energy capture may understate the impact of the crises. In this stretch of early history I calculate scores every half-millennium until 2500 BCE and quarter-millennium between 2500 and 1500 BCE. The 3500 BCE score measures energy capture before the Uruk collapse, and while Mesopotamian energy capture may still have been lower in 3000 BCE than it had been before 3100 (the evidence is not very clear), Egyptian energy capture was definitely higher by 3000 BCE than Mesopotamian had been in 3500. Similarly, the 2250 BCE calculation shows energy capture before the great collapse began, and although Mesopotamia was still in chaos in 2000, order had by then been restored in Egypt. The inevitable result of taking measurements at widely separated points is to smooth the realities of change. On the rare occasions that archaeologists can date sites very precisely, as in the case of Neolithic lake dwellings in central Europe dated by the dendrochronology of their wooden piles, it regularly turned out that what appeared to be a smooth, long-term pattern in fact consisted of multiple short periods of explosive growth and collapse (Shennan 2002).

By 1250 BCE many people in the Western core had become city-dwellers, living in sophisticated archaic states. They had moved far beyond the 12,000 kcal/cap/day energy capture of the early agriculturalist stage in Cook's diagram (Graph 3 on p. 29 above), although comparison of even the richest Late Bronze Age settlements such as Ugarit (Callot 1983, 1994; Yon 1997; destroyed c. 1200 BCE) with classical Greek settlements such as Olynthus (Robinson et al. 1929-52; Cahill 2002; destroyed in 348 BCE) suggests that Bronze Age societies had not matched the classical Greek level of roughly 25,000 kcal/cap/day.

(e) The end of the Bronze Age, 1200-1000 BCE

The collapse that spread over the entire Western core between 1200 and 1000 BCE (Ward and Joukowsky 1992; Drews 1993; Bachhuber and Roberts 2009; Assaf 2010) provides the first clear evidence of falling energy capture. In the worst affected regions (modern Greece and Turkey) cities and elaborate elite monuments disappeared altogether, and even in the least affected area (Egypt) there was a sharp decline in elite activity. The evidence for ordinary people's lives is less clear in Egypt, but in Syria (Akkermans and Schwartz 2003: 360-77), Israel (King and Stager 2001), and the Aegean (Morris 2007), standards of housing, the quantity and quality of material goods, and the scale of exchange networks all fell sharply. Again the lack of large-scale systematic skeletal comparisons is a problem, but in the Aegean, at least, adult age at death declined and there is some evidence for increased morbidity, but trends in adult stature are unclear (Morris 2007).

(f) The Early Iron Age, 1000-500 BCE

Energy capture rose quite sharply from the post-Bronze Age trough around 1000 BCE to he figure of around 25,000 kcal/cap/day calculated for 500 BCE, the beginning of the classical period of Mediterranean antiquity. Most of the data belong to the same categories used for earlier periods. As usual, elite monuments are the most obvious evidence: the 6th-century BCE Persian palaces at Persepolis and the temples and palaces of Babylon dwarf anything from the previous few centuries, as do temples like that of Artemis at Ephesus or Capitoline Jupiter in Rome, on the fringes of the expanding core.

The housing evidence is less straightforward in the core itself, where multi-room rectilinear houses typically covering 50-100 m^2 had been normal for centuries, but in Israel substantial, two-floored "pillared houses" became commoner, larger, and more lavish between 1000 and 500 BCE (Stager 1985), and further west in the Mediterranean multi-room rectilinear houses steadily displaced curvilinear single-room ones. The process had begun in Greece by 750 BCE and was largely complete by 500 (Mazarakis Ainian 1997); in southern Italy and Sicily it began by 600 ended by 400 (Albanese Procelli 2003); and in southern France it began around 400 and was nearly complete by 200 (Py 1993).

In Greece, the evidence for stature is somewhat mixed, but average adult ages at death definitely rose between 1000 and 500 BCE, and morbidity probably declined, suggesting that underlying energy capture also increased (Morris 2007).

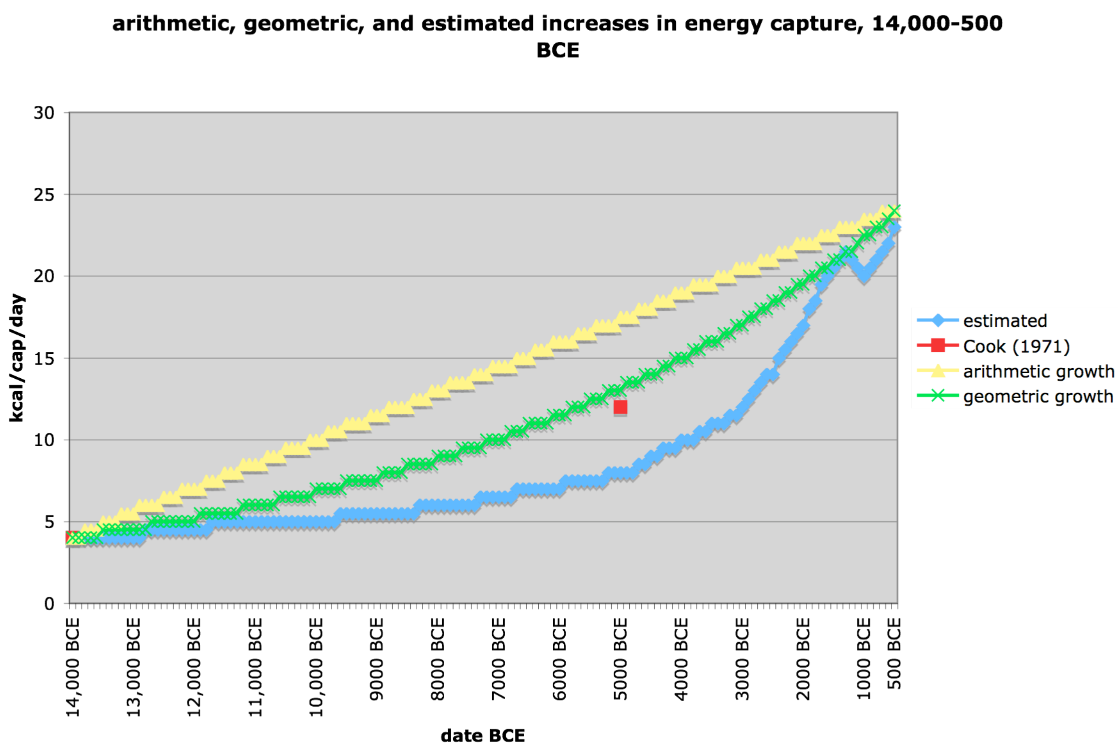
Another very striking change was the spread of iron, which greatly multiplied the effectiveness of muscle-power. The metal had been use occasionally since quite early in the 2nd millennium BCE, but soon after 1100 smiths on Cyprus turned to it more systematically. This was probably a response to the difficulty of obtaining tin for bronze when trade routes collapsed after 1200 BCE, but by the time trade revived on a large scale after 800 the advantages of iron (especially its abundance and cheapness) had become clear, and iron remained the normal material for tools and weapons (Snodgrass 1989). By 1000 BCE nearly all weapons in Greece were made from iron, and around 700 the first iron tools appear in Greece (Mazarakis

Ainian 1998). By then iron weapons were also normal in Italy, southern France, and eastern Spain (Snodgrass 1980).

The incorporation of the central and western Mediterranean between 800 and 500 BCE was the fastest expansion the Western core had yet seen. While economic activity certainly increased in the old southwest Asian core (Bedford 2007), it did so much faster in Greece, Italy, Spain, southern France, and what is now Tunisia (see, e.g., Buxó 2009; Gómez Bellard 2003; Dietler 2007; Morel 2007; Morris 2007; Py 1993). The most easily quantifiable evidence comes from the shipwrecks and pollution records (Graph 7 on p. 46 above).

Estimates are once again hampered by the lack of systematic collections of skeletal, housing, and other forms of evidence outside Greece, but the overall picture seems clear: energy capture rose in the Western core—as fast, probably as it had ever done before—between 1000 and 500 BCE. It rose particularly quickly in the central and western Mediterranean basin.

(g) Calculating the scores



Graph 13. Alternative methods for estimating Western energy capture, 14,000-500 BCE

One way to fill the 13,500-year gap between the energy capture score of 4,000 kcal/cap/day in 14,000 and that of 23,000 kcal/cap/day in 500 BCE would be by simply assuming constant growth rates, either arithmetic or geometric (Graph 13). However, the evidence discussed in this section suggests that that would lose significant amounts of information.

Energy capture clearly increased much faster in the last few millennia BCE than it did in the late Ice Age and immediate post-Ice Age period, meaning that the arithmetic growth curve must be very misleading. A constant geometric increase (of 0.013 percent per annum) would approximate better to the facts, but even that would leave out significant details, such as the Younger Dryas interruption of 10,800-9600 BCE, the apparent acceleration after about 3500 BCE, and the decline in energy capture after 1200 BCE. The best estimated curve seems certain to lie beneath the geometric curve as well as the arithmetic curve; its growth rate will be exponential, but the exponent will generally increase over time.

Other than these basic observations, however, we have no fixed points, and the only way we can proceed is by making estimates and comparing these estimates with the actual archaeological evidence, the comparative evidence, and the scores we have already estimated for the period 500 BCE-2000 CE.

Between 14,000 and 10,800 BCE, energy capture clearly increased, but extremely slowly. Settlements such as pre-Younger Dryas Abu Hureyra reveal people capturing more energy than late ice Age sites such as Ohalo. I would guess that the increase was something like 1,000 kcal/cap/day, from 4,000 to 5,000 kcal/cap/day (i.e., a 25 percent increase across 3,200 years, or 0.007 percent per annum). I have no firm basis for this proposal. Possibly the increase in the size and sophistication of houses, the complexity of food preparation, and the expansion of material culture represented just 500 kcal/cap/day (a 12.5 percent increase); perhaps it represented 2,000 kcal/cap/day (a 50 percent increase). Both those numbers seem extreme to me, but even if one of them is closer to the truth than my 1,000 kcal/cap/day estimate, the amount of change between 14,000 and 10,800 BCE was still very small, and assuming that energy capture in 10,800 BCE was 4,500 kcal/cap/day or 6,000 kcal/cap/day rather than 5,000 kcal/cap/day would only make a minor difference to the calculations that follow.

As mentioned in section (b) above, there are conflicting signs in the evidence for the Younger Dryas period (10,800-9600 BCE), so I have decided simply to treat energy capture as flat across this 1,200-year period. Again, this may be a mistake; perhaps energy capture fell back (though not all the way to 14,000 BCE levels) or perhaps it continued to rise (though not as quickly as between 14,000 and 10,800 BCE). As with the earlier period, though, the amounts involved are tiny, and errors in estimation are in any case as likely to cancel each other out as to compound each other.

Between 9600 and 3500 BCE the increase in energy capture seems to have been far larger than that between 14,000 and 10,800 BCE. Cook (1971) estimated that it had already risen to 12,000 kcal/cap/day by 5000 BCE, just slightly below the level of 13,000 kcal/cap/day implied by the geometric curve. The evidence now available makes that seem much too high. Cook may have assumed—as archaeologists sometimes did in the mid-20th century—that the agricultural revolution was a single, fairly rapid transformation, whereas we now know that cultivation and domestication were processes spread across about 4,000 years, and were merely the first stages of an ongoing secondary products revolution that lasted in southwest Asia until about 4000 BCE (Sherratt 1997). I suggest that total energy capture roughly doubled between 9600 and 3500 BCE, from about 5,500 kcal/cap/day to 11,000 kcal/cap/day (a rate of 0.013 percent per annum, almost double that of the period 14,000-10,800 BCE), rather than more than doubling by 5000 BCE, as Cook suggested. His estimate gives a growth rate of 0.017 percent per annum between 10,800 and 5000 BCE; if that were extended out to 3500 BCE it would produce a score of 15,500 kcal/cap/day in that year. If, as I suggest below, energy capture almost doubled again between 3500 and 1200 BCE, Late Bronze Age energy capture would have reached 30,000 kcal/cap/day—almost the same as the score at the height of the Roman Empire in the 1st century CE, Song dynasty China in the 12th century CE, or the west European core and China around 1600 CE.

That seems very improbable. If Cook's estimate of 12,000 kcal/cap/day in 5000 BCE were correct, the only way to preserve a plausible relationship with later figures would be by assuming a drastic slowdown in the growth rate after 5000 BCE. If it fell to just 0.015 percent per annum (lower than Cook's estimate of 0.017 percent for the period 9600-5000 BCE), that would bring the score for 1200 BCE down to 21,000 kcal/cap/day, as in my estimate. However, the archaeological evidence is hard to reconcile slower growth after 5000 BCE than before. It seems to me that Cook's energy-capture estimate for the Western core around 5000 BCE of 12,000 kcal/cap/day must be too high. If energy capture increased roughly 50 percent between 10,800 and 5000 BCE, from 5,500 to about 8,000 kcal/cap/day (rather than more than doubling, from 5,500 to 12,000 kcal/cap/day, as Cook suggested), then increasing by roughly another one-third (from 8,000 to 11,000 kcal/cap/day) between 5000 and 3500 BCE, we get a much more plausible picture of Neolithic energy use and its relationship to the Bronze Age. I suggest that energy capture increased to

8,000 kcal/cap/day in 5000 BCE and then to 11,000 kcal/cap/day in 3500 BCE.

Between 3500 and 1300 BCE—roughly from the age of Uruk to the age of Ramses—I suggest that energy capture roughly doubled again, from 11,000 to 21,500 kcal/cap/day (a rate of increase of 0.029 per cent per annum, just over twice as fast as between 9600 and 3500 BCE, and four times as fast as between 14,000 and 10,800 BCE). If this is correct, my estimated growth curve caught up with the geometric curve (Graph 13 on p. 69 above) in the 13th century BCE. The figure in 1300 BCE could, of course, be somewhat higher or lower, but any really big changes (say, down to 18,000 or up to 25,000 kcal/cap/day) would mean assuming either strangely slow or strangely fast rates of change in the early 1st millennium BCE.

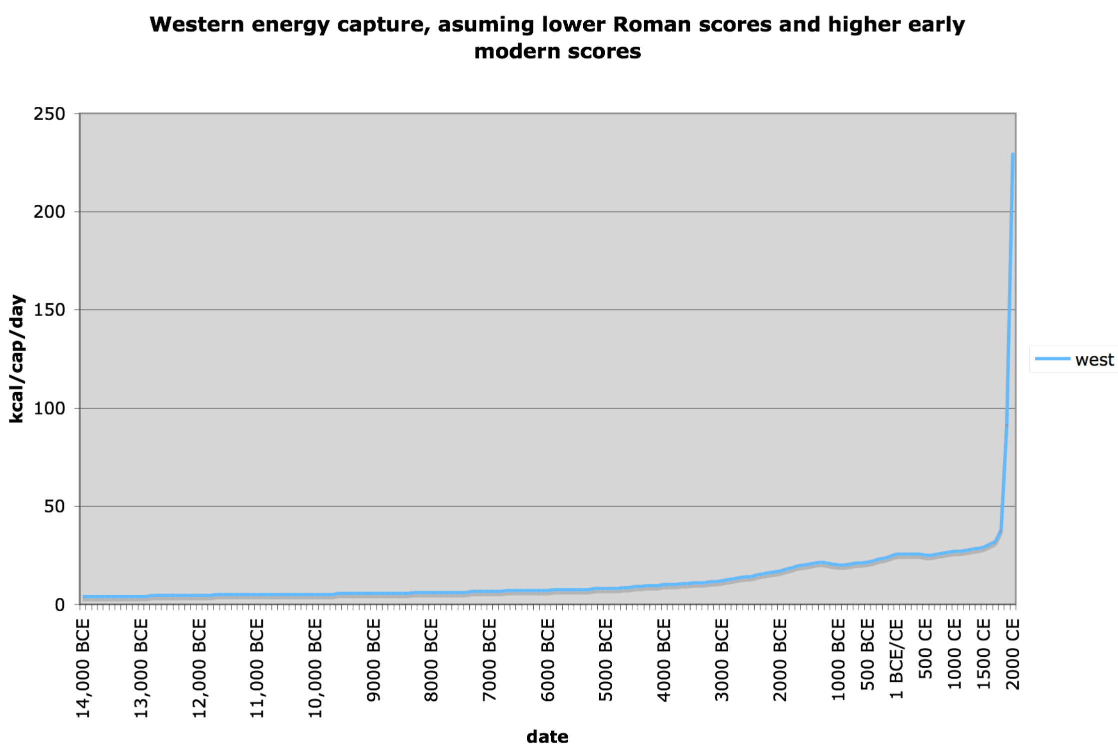
The scale of decline in energy capture between 1300 and 1000 BCE is hard to estimate. I have suggested that the figure fell slightly during the 13th century, from 21,500 to 21,000 kcal/cap/day, then faster, from 21,000 to 20,000 kcal/cap/day, between 1200 and 1000 BCE (a rate of change of −0.025 percent per annum between 1200 and 1000 BCE). The bottom of the trough may have been a little deeper, in which case growth in the early 1st millennium must have been slightly faster to reach 23,000 kcal/cap/day by 500 BCE, or slightly shallower, in which case subsequent growth must have been a little slower. However, the claim made by some archaeologists in the 1990s that there was really little or no post-1200 BCE collapse (e.g., S. P. Morris 1992) seem to me misguided (I. Morris 2007), rather like the suggestions that there was no post-Roman collapse.

If these numbers are roughly correct, energy capture must have risen by about 15 percent between 1000 and 500 BCE, from approximately 20,000 to 23,000 kcal/cap/day (a growth rate of 0.029 percent per annum, just slightly faster than the rate estimated for 3500 through 1200 BCE). By my estimates, energy capture rose a further 35 percent between 500 and 1 BCE (from 23,000 to 31,000 kcal/cap/day).

In graph 7 on p. 46 above, showing shipwrecks and lead pollution as proxies for long-distance trade and metalworking, 15 percent of the 1st-millennium BCE increase comes before 500 BCE and the other 85 percent after 500 BCE. This may mean that the estimates for 1000 BCE (and, by implication, for 1300 BCE) are too low; or it may just reflect the fact that the bulk of the large population increase in the 1st-millennium BCE Mediterranean (Scheidel [2007: 42] estimates that the population roughly quadrupled between 1200 BCE and 150 CE) came after 500 BCE, meaning that while the aggregate increase in trade and industry seems to be heavily weighted toward the late 1st millennium, the per capita increase was less heavily weighted.

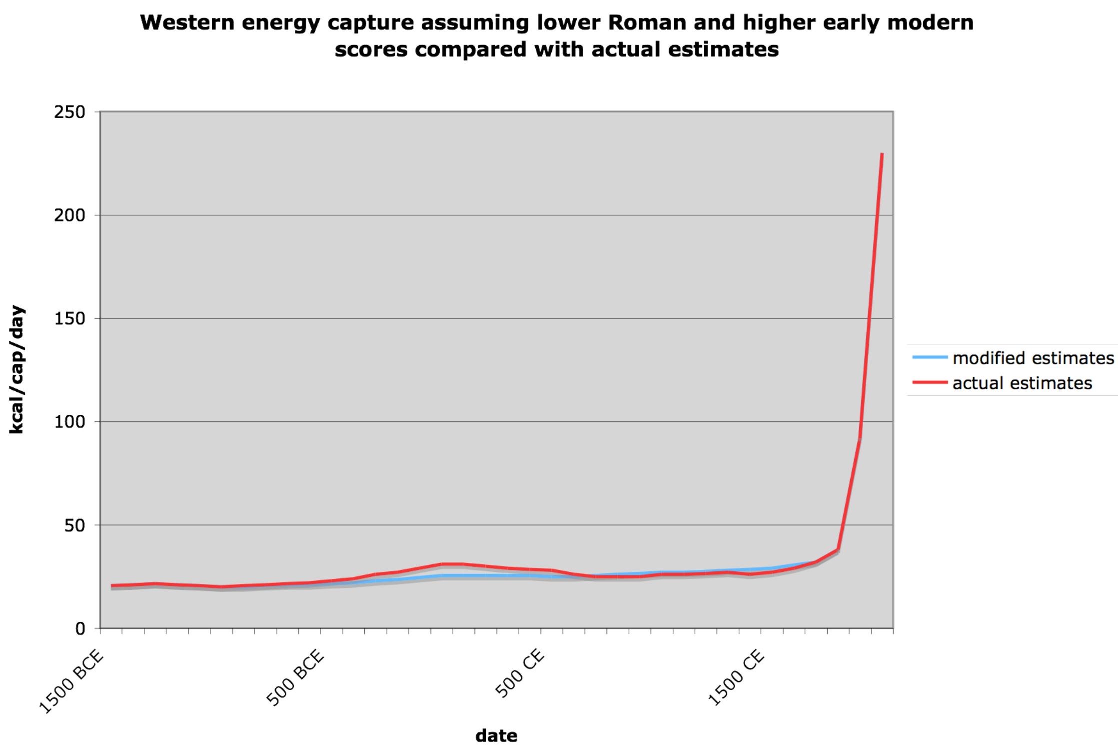
[8.4.6] *Western energy capture: discussion*
Graphs 4 and 5 on pp. 35-36 above show the scores I have calculated for Western energy capture for the whole period between 14,000 BCE and 2000 CE. By its very nature, such graphs involve a lot of approximation. It is hard to imagine that every number could possibly be correct, which means that the appropriate question to ask is not whether all the numbers are right—we can be sure they are not—but whether they can be so wrong that they seriously misrepresent the shape of the history of Western energy capture.

To this question, I think the answer must be no. The scores are certainly within the right order of magnitude, and, for reasons I discuss in *Why the West Rules—For Now* (Morris 2010: 640-45), the range of systematic errors is probably less than ± 20 percent. The most serious concern, however, must be how much the *un*-systematic errors distort the shape of the graph.



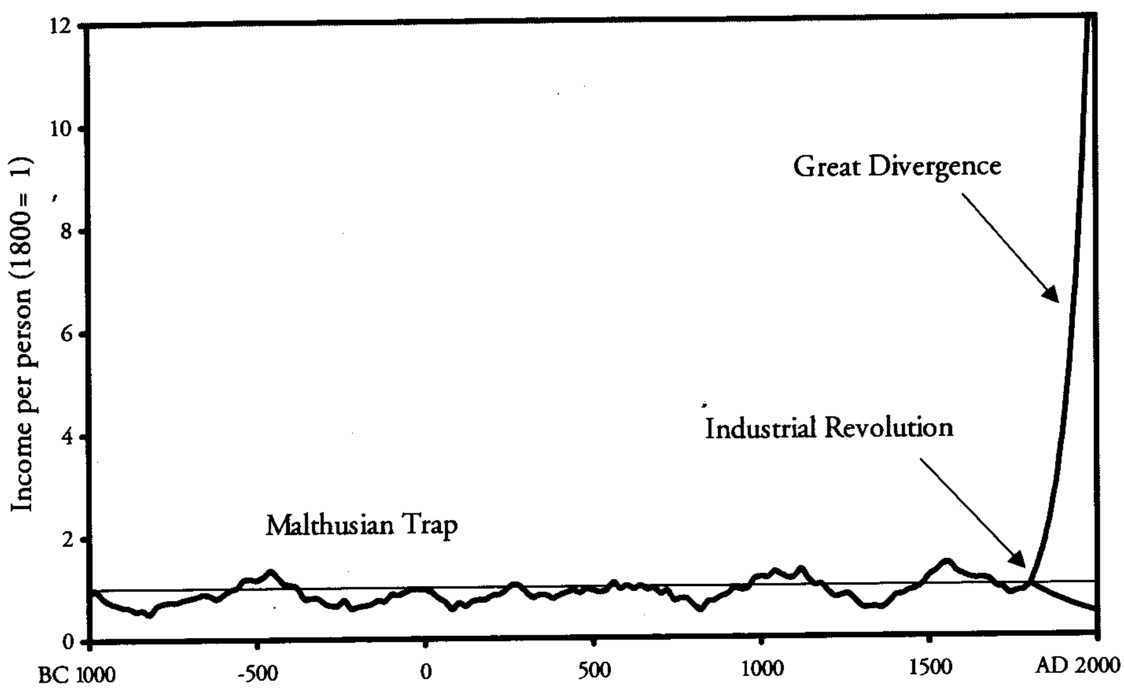
Graph 14. Western energy capture, 14,000 BCE-2000 CE, assuming lower Roman rates and higher early modern rates

Graph 14 shows what the energy curve would look like if, for example, the increase in energy capture across the 1st millennium BCE was just half what I have actually estimated (i.e., from 20,000 kcal/cap/day in 1000 BCE to 25,500 kcal/cap/day rather than 31,000 kcal/cap/day in 1 BCE/CE) while the increase between 700 and 1500 CE was twice as large as I estimated (i.e., from 25,000 to 29,000 kcal/cap/day rather than from 25,000 to 27,000 kcal/cap/day). These are rather drastic revisions, which strike me as difficult to justify from the surviving evidence; yet they make very little difference to Graph 14. The increase in energy capture between 1000 BCE and 2000 CE becomes smoother (this is easier to see in Graph 15, which presents both the actual estimates and these revised estimates and covers just the period 1500 BCE–2000 CE), but the basic pattern remains the same.



Graph 15. Comparison of the actual estimates of Western energy capture, 1500 BCE-2000 CE, with the assumption of lower Roman and higher early modern scores

We can experiment with any number of hypothetical modifications, but the main value of such thought experiments is to show just how radically we would need to change the scores to have a serious impact on the fundamental shape of the history of Western energy capture. The basic pattern—a very long period of extremely slow growth from the end of the Ice Age to the rise of the state (i.e., from about 14,000 to about 3000 BCE), accelerating but still very slow growth in the age of early states and empires (roughly 3000-1 BCE), fluctuations pressing against an agrarian ceiling slightly above 30,000 kcal/cap/day (roughly 1–1600 CE), a brief period when the agrarian ceiling was pushed upward (1600–1800 CE), and finally a (so far) brief period of explosive growth (1800 to present)—is very clear.



Graph 16. Gregory Clark's (2007) reconstruction of income per person across the last 3,000 years

Economists regularly assume that nothing important changed until the industrial revolution. Gregory Clark's claim that "the average person in the world of 1800 [CE] was no better off than the average person of 100,000 BC" (Clark 2007: 1) and his accompanying graph (Graph 16), representing premodern living standards as a random walk around a Malthusian ceiling, are unusual only in being so explicit, but they are mistaken. There were enormous increases in energy capture between the end of the Ice Age and 1800 CE. As Malthus himself recognized, however, these must be divided into food and non-food calories. Increases in food calories per unit of land were quickly consumed when people converted the energy windfall into more babies, but increases in non-food energy capture were not canceled out, and the archaeological record attests a striking accumulation across the last sixteen millennia. The upward trend in Graphs 4 and 5 was interrupted by various collapses, most strikingly after 1200 BCE, 200 CE, and 1300 CE, but each these wiped out only part of the preceding increase and proved temporary.

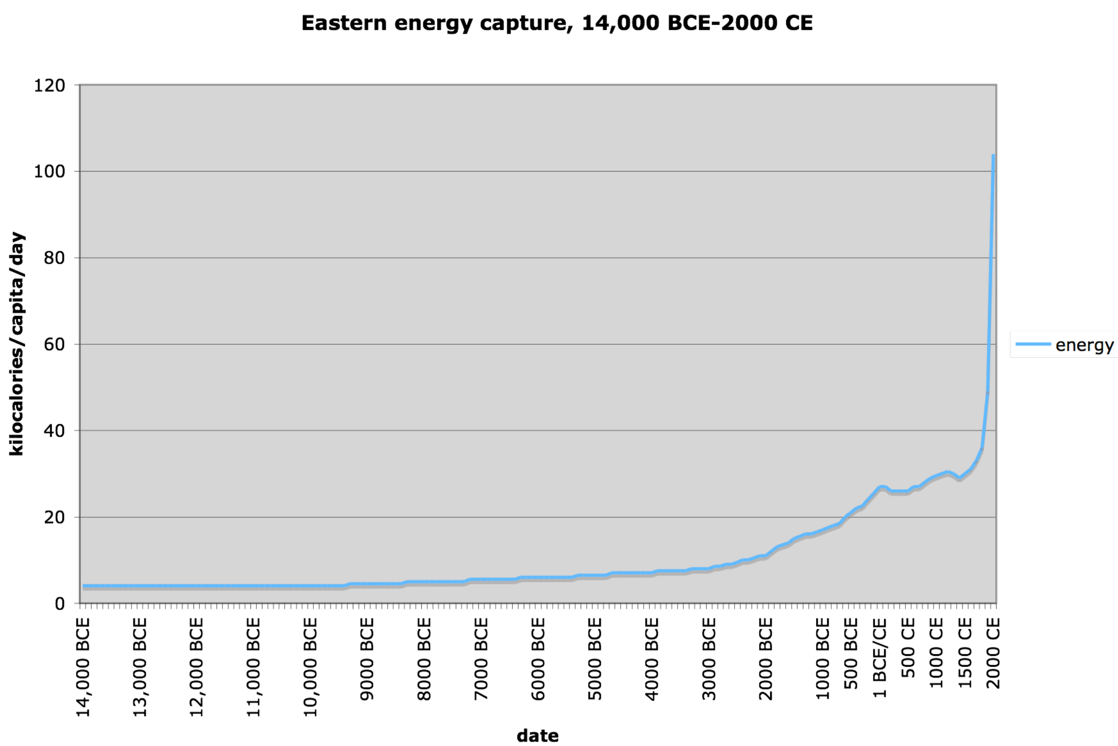
[8.5] *Estimates of Eastern energy capture*

Table 5: Eastern energy capture, 14,000 BCE-2000 CE

14,000 BCE:	4,000 kcal/cap/day = 4.36 points
13,000 BCE:	4,000 kcal/cap/day = 4.36 points
12,000 BCE:	4,000 kcal/cap/day = 4.36 points
11,000 BCE:	4,000 kcal/cap/day = 4.36 points
10,000 BCE:	4,000 kcal/cap/day = 4.36 points
9000 BCE:	4,500 kcal/cap/day = 4.90 points
8000 BCE:	5,000 kcal/cap/day = 5.45 points
7000 BCE:	5,500 kcal/cap/day = 5.99 points
6000 BCE:	6,000 kcal/cap/day = 6.54 points
5000 BCE:	6,500 kcal/cap/day = 7.08 points
4000 BCE:	7,000 kcal/cap/day = 7.63 points
3500 BCE:	7,500 kcal/cap/day = 8.17 points
3000 BCE:	8,000 kcal/cap/day = 8.72 points
2500 BCE:	9,500 kcal/cap/day = 10.35 points
2250 BCE:	10,500 kcal/cap/day = 11.44 points
2000 BCE:	11,000 kcal/cap/day = 11.99 points
1750 BCE:	13,000 kcal/cap/day = 14.17 points
1500 BCE:	15,000 kcal/cap/day = 16.35 points
1400 BCE:	15,500 kcal/cap/day = 16.89 points
1300 BCE:	16,000 kcal/cap/day = 17.44 points
1200 BCE:	16,000 kcal/cap/day = 17.44 points
1100 BCE:	16,500 kcal/cap/day = 17.98 points
1000 BCE:	17,000 kcal/cap/day = 18.52 points
900 BCE:	17,500 kcal/cap/day = 19.07 points
800 BCE:	18,000 kcal/cap/day = 19.61 points
700 BCE:	18,500 kcal/cap/day = 20.16 points
600 BCE:	20,000 kcal/cap/day = 21.79 points
500 BCE:	21,000 kcal/cap/day = 22.88 points
400 BCE:	22,000 kcal/cap/day = 23.97 points
300 BCE:	22,500 kcal/cap/day = 24.52 points
200 BCE:	24,000 kcal/cap/day = 26.15 points
100 BCE:	25,500 kcal/cap/day = 27.79 points
1 BCE/CE:	27,000 kcal/cap/day = 29.42 points
100 CE:	27,000 kcal/cap/day = 29.42 points
200 CE:	26,000 kcal/cap/day = 28.33 points
300 CE:	26,000 kcal/cap/day = 28.33 points
400 CE:	26,000 kcal/cap/day = 28.33 points
500 CE:	26,000 kcal/cap/day = 28.33 points
600 CE:	27,000 kcal/cap/day = 29.42 points
700 CE:	27,000 kcal/cap/day = 29.42 points
800 CE:	28,000 kcal/cap/day = 30.51 points
900 CE:	29,000 kcal/cap/day = 31.06 points
1000 CE:	29,500 kcal/cap/day = 32.15 points
1100 CE:	30,000 kcal/cap/day = 32.69 points

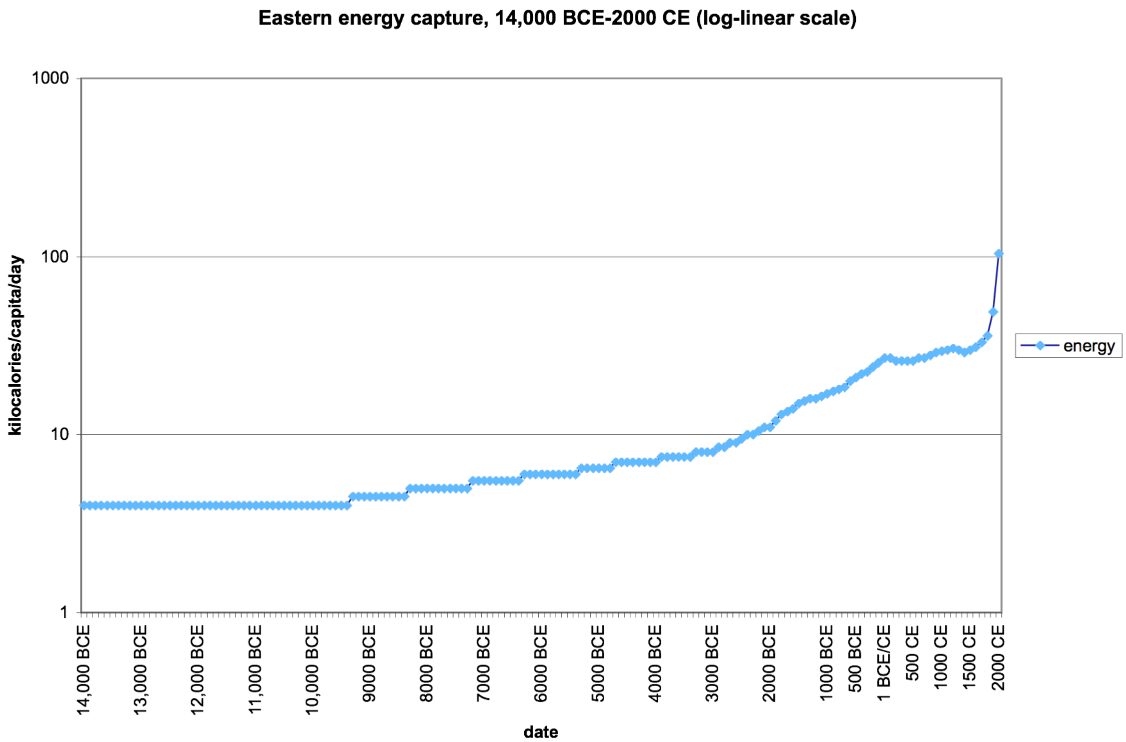
1200 CE:	30,500 kcal/cap/day = 33.24 points
1300 CE:	30,000 kcal/cap/day = 32.69 points
1400 CE:	29,000 kcal/cap/day = 31.06 points
1500 CE:	30,000 kcal/cap/day = 32.69 points
1600 CE:	31,000 kcal/cap/day = 33.78 points
1700 CE:	33,000 kcal/cap/day = 35.96 points
1800 CE:	36,000 kcal/cap/day = 39.23 points
1900 CE:	49,000 kcal/cap/day = 53.40 points
2000 CE:	104,000 kcal/cap/day = 113.33 points

Table 5, Graph 17, and Graph 18 show my estimates for Eastern energy capture since 14,000 BCE.



Graph 17. Eastern energy capture, 14,000 BCE-2000 CE

Much less research has been done on Eastern energy capture than on Western, and there is a particular dearth of quantitative estimates. Yet while much work remains to be done, the main outlines are reasonably clear. At the end of the last Ice Age, around 14,000 BCE, per capita energy capture in the most favored regions of the East was rather similar to that in the West, at around 4,000 kilocalories per capita per day (kcal/cap/day). For geographical reasons, Eastern scores initially rose more slowly than those in the West, with the first clear signs of cultivation and domestication of plants running about 2,000 years behind those in the Western core. The increase in Eastern scores began accelerating by 3000 BCE. As in the West, there was a serious collapse in the early 1st millennium CE. Eastern energy capture quickly recovered, and was moving upward again by 400 CE, but did not reach the agrarian ceiling of roughly 30,000 kcal/cap/day until after 1000 CE. After another serious collapse between 1200 and 1400 CE the Eastern score returned to the agrarian ceiling by 1600, passed it by 1700, and then grew rapidly (relative to earlier periods) across the 19th and 20th centuries.



Graph 18. Eastern energy capture, 14,000 BCE-2000 CE, log-linear scale

In comparative terms, the scores for the Eastern core seem to have been lower than those for the Western core throughout prehistory and antiquity and again in the 19th and 20th centuries CE, but were higher in what Western historians call the Middle Ages and early modern times, from roughly the mid-1st through mid-2nd millennium CE. Refining the comparisons, though, is more difficult.

In this section I will begin with the most recent period, since 1800 CE, and then (as in my analysis of Western energy capture jump back in time to better known periods (first the Song dynasty of 960–1279 CE, and then the Han dynasty of 206 BCE–220 CE) before filling in the gaps. Finally I will turn to the prehistoric East.

[8.5.1] *The recent past, 1800-2000 CE*

As in the Western core, high-quality statistics are available for energy capture in 2000 CE, putting total food + non-food per capita energy capture in the Eastern core (in Japan) at about 104,000 kcal/cap/day (Food and Agriculture Organization 2006: Table 4; United Nations Organization 2006)—less than half the 230,000 kcal/cap/day consumed in the United States, but much higher than in any earlier period of Eastern (or Western) history.

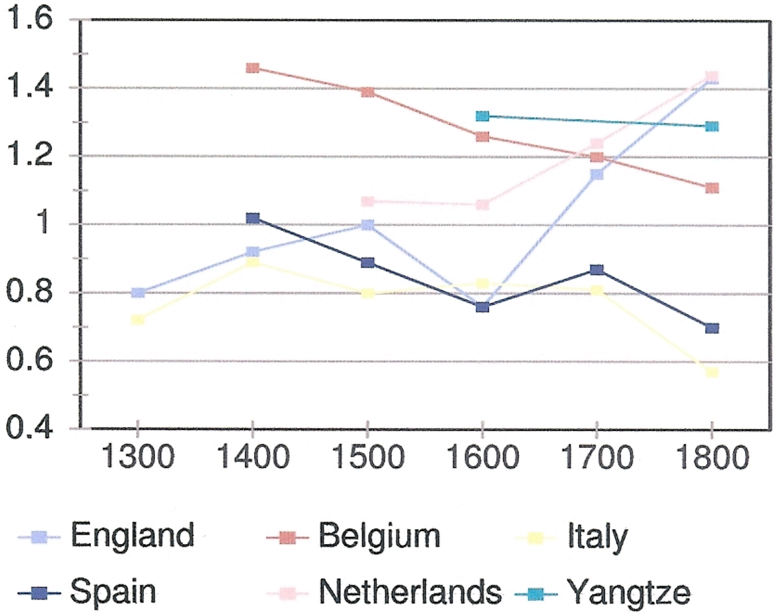
Reliable government statistics do not go back very far in the East, and (as in the West) the problems are compounded by the scarcity of quantitative data on biomass used for fuel, housing, clothing, etc., in peasant households (cf. Smil 1991, 1994; Buck 1930, 1937; Perkins 1969). In 1900 Japan burned 3 million tons of coal per year (roughly 500 kg of coal per person per year, or a little over 500 kcal/cap/day, as compared to 181 million tons = 4.36 tons/cap/year = roughly 40,000 kcal/cap/day in Britain in 1903) and only a tiny amount of oil (see statistical tables in G. C. Allen 1946 and T. C. Smith 1955). Biomass use, however, became efficient as well as intensive as population pressure increased across the 18th and 19th century and the resource base was steadily degraded (Totman 1989, 1993: 223-79; Mitchell 1988: 258), probably rivaling that in the advanced organic economies of 18th-19th century northwest Europe. Put together, these various sources suggest energy capture just under 50,000 kcal/cap/day in the Eastern core in Japan in 1900.

Early 20th-century peasant life in northern China is relatively well documented (see especially Buck 1930, 1937; Perkins 1969; P. Huang 1985). Coal and bean curd fertilizer were widely used in the 19th century. By 1900 living standards were typically lower than in Japan and in some places were actually falling, but energy capture must have been well over 40,000 kcal/cap/day.

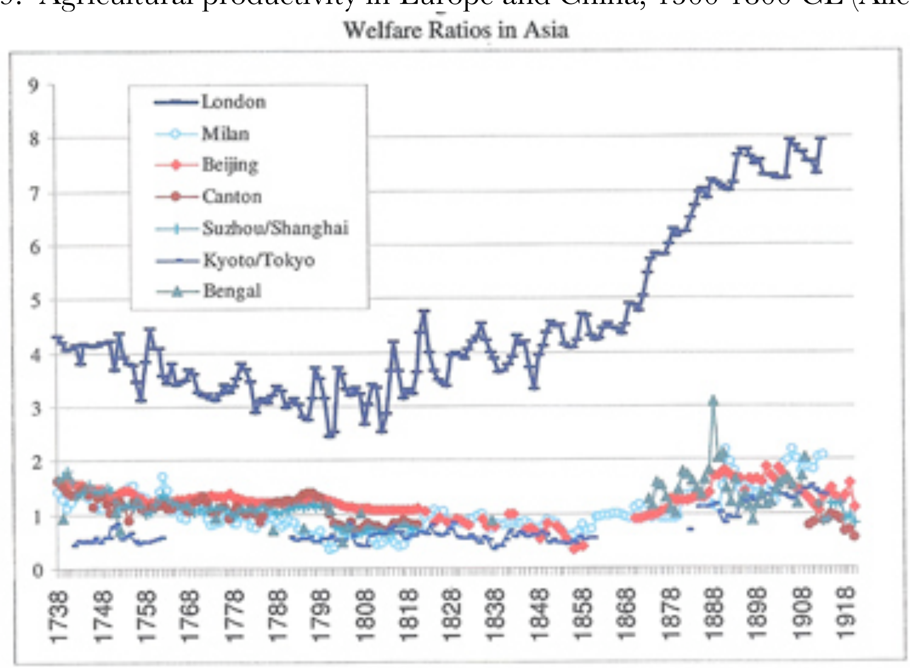
Standards of living in the 19th-centuy East (and particularly China) have been intensely debated since the 1990s, to the point that they have become the major battleground between long-term lock-in and short-term accident theories of Western rule (discussed in Morris 2010: 11-21). For most of the 20th century, the dominant theory among historians was that the Chinese economy had stagnated between 1400 and 1900. Angus Maddison (2003), for instance, estimated that Chinese GDP/cap rose from $450 to $600 (PPP, Geary-Khamis 1990 international dollars) between 1000 and 1500 CE, then stayed at $600 for the entire period between 1500 and 1820. Similarly, Dwight Perkins (1969) suggested that after vigorous growth and innovation during the Middle Ages, agriculture reached its limits in Yuan dynasty times (1279-1368), and thereafter the best practices spread across China from the agrarian core in southern China but few important new techniques were added. Mark Elvin (1973) made a broader argument that after coming close to an industrial takeoff in Song dynasty times (960-1279), China entered what he called a "high-level equilibrium trap," in which traditional muscle- and water-powered technologies had become as efficient as they could get, but there were insufficient incentives to make the leap to fossil-fuel technologies. Implicitly or explicitly, views of this kind suggested that per capita energy capture in the Eastern core barely changed between the establishment of the Ming dynasty in 1368 and the intrusion of Europeans in the 1840s.

These theories came under serious attack in the 1990s, in part because the People's Republic had opened many of its Ming-Qing archives to scholars in the 1980s (Zurndorfer 2003). Historians found abundant evidence for economic change, especially in Qing times (1644-1911), and Kenneth Pomeranz (2000) in particular argued that the trajectory in the most economically advanced parts of 18th-19th century China, in the Yangzi delta, had far more similarities with than differences from the trajectory in western Europe. The forms of its proto-industrialization were similar, he argued, as was its industrious revolution. Pomeranz also suggested that living standards were rising in Qing China despite rapid population growth, calculating that 19th-century Chinese adult males typically consumed between 2,386 and 2,651 food calories per day, roughly the same as those in Britain (Pomeranz 2000: 39). Chinese consumption of sugar (Mazumdar 1998), tobacco, candles, furniture, and meat also seems to have risen, and cotton clothing spread throughout the population (Pomeranz 2000: 91-98).

The older, more pessimistic picture of agricultural involution in the East between 1400 and 1900 still has defenders (e.g., P. Huang 1990; 2002), but as long-term data on Eastern real wages and agricultural yields improves (Allen 2006; Allen et al. 2007), it increasingly looks as if some compromise between the two theories makes most sense. As the pessimists argue, output per agricultural worker did decline between 1600 and 1800 (Graph 19); but it remained very high, and as late as 1700, farm laborers in the Yangzi delta were probably more productive than those anywhere in Europe. By contrast, as the optimists suggest, real wages did increase slightly in Beijing between 1738 and 1900 (Graph 20), but they remained very low, having far more in common with wages in backward southern Europe than those in dynamic northwest Europe. In 1738, real wages in Beijing, Shanghai, Suzhou, and Tokyo bought less than half as much as wages in London or Amsterdam, but were roughly comparable with those in southern (Milan) or central (Leipzig) Europe (and, Allen [2009a] suggests, those in the Roman Empire at the time of Emperor Diocletian's Price Edict in 301 CE). Eastern wages remained very similar to those in southern European until 1918, but by 1820 central European wages had pulled away and were gaining on those in Britain.

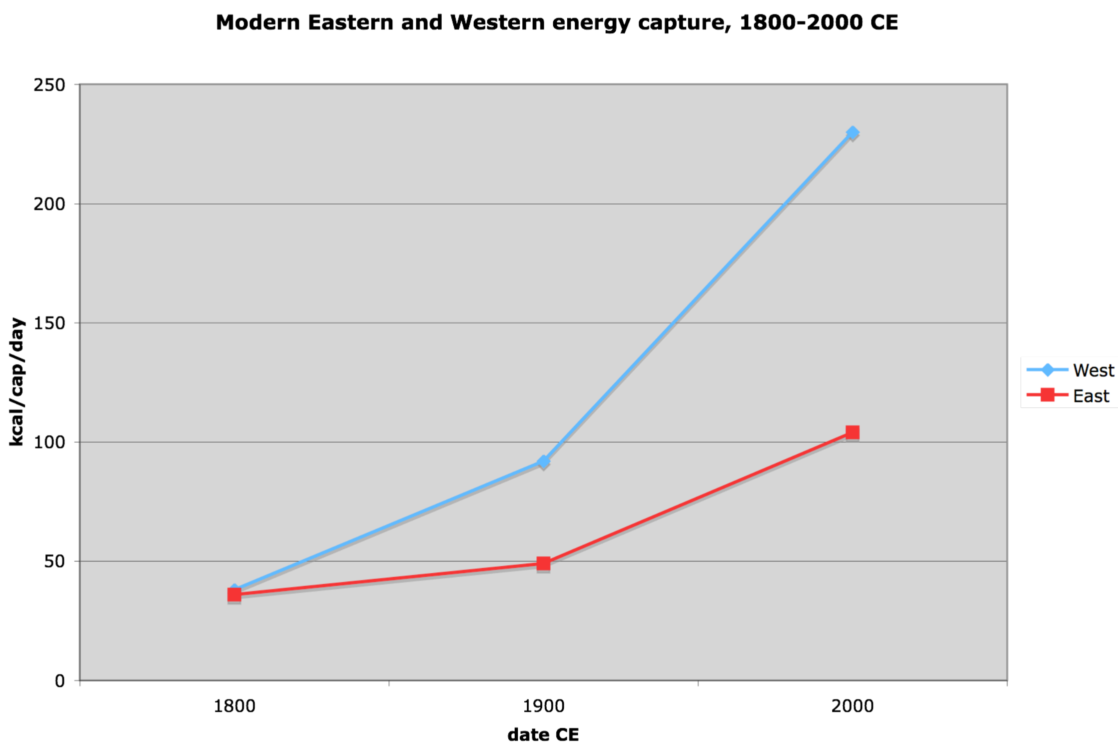


Graph 19. Agricultural productivity in Europe and China, 1300-1800 CE (Allen 2006)



Graph 20. Real wages in Europe and Asia, 1738-1918 CE (after Allen et l. 2007)

We can conclude that in 1800 energy capture in the Eastern core was lower than in the Western core, but not *much* lower. By my calculations, Western energy capture was around 38,000 kcal/cap/day at that point. In the Eastern core agricultural output was high and a great deal of coal was being used for heating and cooking, but there was no steam power, and the real wage data suggest that overall living standards were lower than in northwest Europe. I suggest that typical Eastern energy capture in the core (northern and coastal China plus Japan) was around 36,000 kcal/cap/day. It could not have been much above this level without catching up with Western energy levels, nor could it have fallen much below without sinking to the level of the Roman Empire, which seems unlikely.



Graph 21. Eastern and Western energy capture, 1800-2100 CE

These figures for energy capture in the Eastern core (Graph 21) suggest that it began the modern period (for these purposes, around 1800 CE) only slightly behind the West. Contrary to the traditional/pessimistic view, the 19th century did see rising energy capture, but the increase was much smaller than in the West. Rather than an Eastern decline, the redistribution of global power in the 19th-century West's favor was driven by the Western takeoff. Likewise, the East's growing global stature in the 20th century was driven not by a Western decline but by the East learning to exploit fossil energy sources that had been pioneered by Westerners.

[8.5.2] *Song dynasty China (960–1279 CE)*

The Song dynasty probably saw the peak of premodern energy capture in China. Population grew very rapidly, from around 50 million in the early 10th century to over 120 million by 1200, but all the signs suggest that living standards and energy capture rose even faster.

The clearest textual evidence comes from metallurgy, with its vast demands for fuel. Fifty years ago the economic historian Robert Hartwell reanalyzed Song tax receipts and argued that 11th-century iron production had been 20 to 40 times greater than historians had previously recognized. He calculated that in 1078 total taxed output was 75,000 to 150,000 tons, a 12-fold increase over Chinese production in 850 CE. Moreover, Hartwell pointed out, Chinese output in 1078 was roughly 2.5 times higher than that of England and Wales in 1640, more than half as much as was produced in Europe in 1700, and about the same as was produced in China each year between 1930 and 1934 (Hartwell 1962: 155; cf. Hartwell 1966, 1967).

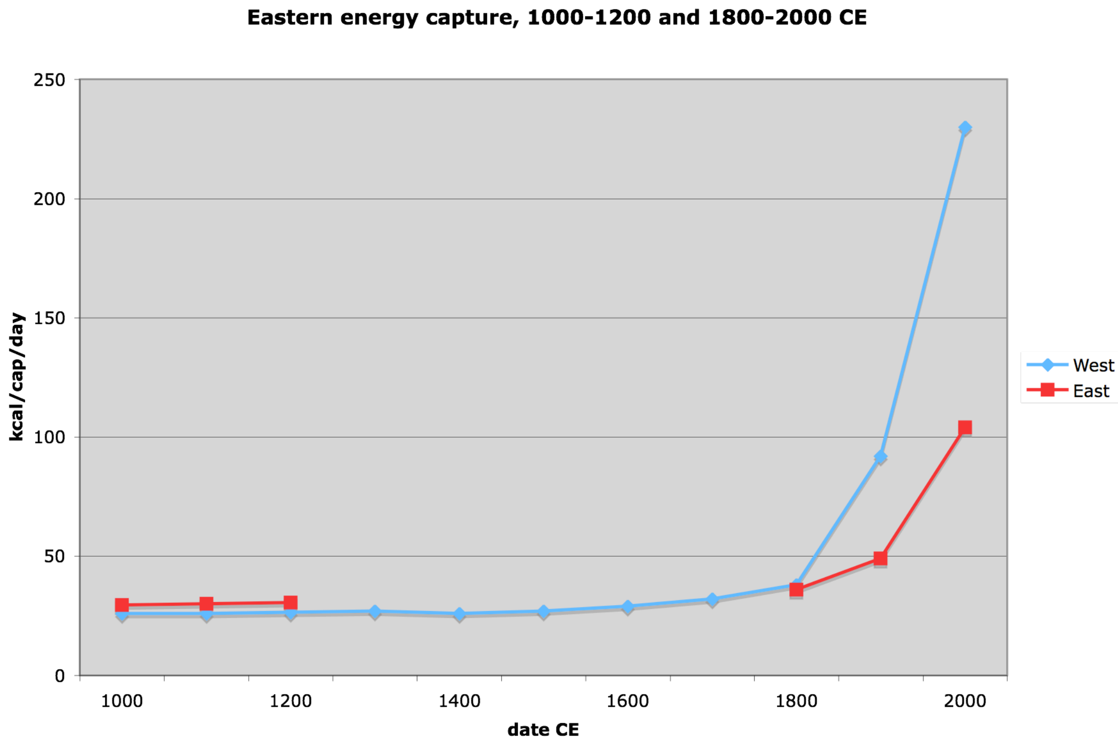
Hartwell's analysis of the texts has been criticized, and in his volume of *Science and Civilisation in China*, Peter Golas (1999: 170 n. 475) suggested that his iron output figures were off by an entire order of magnitude. More recently, however, Donald Wagner has concluded in his own volume of *Science and Civilisation in China* (2008: 279-80; cf. Wagner 2001) that while Hartwell's readings of the difficult texts are flawed, his numbers must be roughly right. The Chinese historian Qi Xia has independently concluded that the enormous expansion of iron tools in farming meant that the needs of 11th-century peasant households must have accounted for 70,000 tons p.a. (cited from Kuhn 2009: 307-308 n. 36); and the state's demand for iron coins and weapons may have been even larger. Copper production was equally extraordinary, increasing fivefold from 2,420 tons in 997 to 12,982 tons in 1070—more than the entire world would be producing in 1800 CE (Golas 1999: 376-83; Kuhn 2009: 231). In the 11th and 12th centuries the byproducts of Chinese metalworking for the first time left traces in the Greenland and Antarctic ice caps, just as Roman silver processing had done a thousand years before (Hong et al. 1996).

Hartwell consistently likened the expansion of Chinese metallurgy to that in England between 1540 and 1640, and suggested that—like the English example—one consequence was the increasing substitution of fossil fuels for charcoal in iron smelting. If Chinese ironmasters had powered their foundries solely with charcoal, in 1080 they would have needed to burn 22,000 mature trees, far beyond what was available around Kaifeng. Instead, they learned to smelt iron with coke and turned to large-scale coal mining. By 1050 so much coal was being mined that it was 30–50 percent cheaper than wood for household cooking and heating. By 1075 Kaifeng had special markets that dealt in nothing but coal, and government documents from 1096 discuss the coal supply without even referring to wood as a heat source (Hartwell 1962: 159-60). Confirmation of this shift comes from recent analyses of iron and steel artifacts found in Mongolia, on the edge of the Song Empire, which show that coal replaced charcoal for smelting in the 10th-12th centuries (Park et al. 2007, 2008).

Unfortunately there are as yet no statistics from excavated shipwrecks, animals bones, etc., to parallel those from the Western core between 900 BCE and 800 CE (see Graph 7 on p. 46 above), but the qualitative evidence from literature, art, and standing remains testifies to the huge expansion of trade, commerce, and manufacturing, and the widespread use of spinning machines and watermills (see Elvin 1973; Kuhn 2009: 213-32). The numerous Song dynasty shipwrecks that have been looted off the Guangdong coast since the 1980s suggest that ships were becoming bigger and cargoes richer, and in 2007 the properly excavated Nanhai 1 ship (http://news.bbc.co.uk/2/hi/asia-pacific/7156581.stm) confirmed this.

Houses may also have become more substantial, and in 12th-century Hangzhou two-story buildings were the norm, in striking contrast to older Chinese cities (Kuhn 2009: 205). Most people, however, probably still lived on in one- and two-room wooden huts (Ruitenbeek 1993). There is some evidence for the growth of mass markets for ceramics and other household goods, but I am not aware of any statistical studies of domestic assemblages.

The 11th and 12th centuries certainly saw high (by premodern standards) levels of energy capture, but it is difficult to fix them in absolute terms. The scale of iron production and the presence of Chinese pollution in the ice cores suggests that energy capture was somewhere around the level attained by the Roman Empire 1,000 years earlier (31,000 kcal/cap/day) or that reached in western Europe around 1700 CE (32,000 kcal/cap/day); the absence of anything we might call an industrial revolution, however, suggests that it did not approach what we see in western Europe by 1800 (38,000 kcal/cap/day). I tentatively suggest that Song-era energy capture remained very slightly below Roman levels, hitting 30,000 kcal/cap/day in 1100 and perhaps nudging just slightly over that figure by 1200 (Graph 22 [link to 17.22]). A figure slightly above Roman levels, perhaps even matching the European score of 32,000 kcal/cap/day in 1700 CE, seems equally plausible, but much higher or much lower figures—reaching, say, 35,000 kcal/cap/day or sinking below 25,000 kcal/cap/day—seem very unlikely.



Graph 22 Song and modern energy capture in the East, 1000-1100 and 1800-2000 CE

[8.5.3] *Early modern China (1300-1700 CE)*

In the 1960s-70s, economic historians regularly argued that after significant increases in productivity and living standards in the medieval period, Chinese agriculture and industry stagnated between 1400 and 1800, and then actually went backward in the 19th century, under the impact of civil wars, mismanagement, and Western imperialism.

There are several versions of this thesis. In a pioneering study of agricultural output between 1368 and 1968, Dwight Perkins (1969) built on John Buck's research in the 1920s-30s (Buck 1930, 1937) to suggest that the 15th-19th centuries saw best farming practices spreading from the Yangzi valley to northern China and then, thanks to Qing-era colonization, to Shaanxi and even further west. Perkins (1969: 15) calculates that rice output in the Yangzi delta had reached very high levels by 1300; at 3.5 tons/hectare it was more than double the level of English output by area in 1800 (1.7 t/ha), albeit only one-third the level of England in 1800 when measured as output per worker (0.3 t/ha vs. 0.92 t/ha). Chinese productivity also compared extremely well to that of irrigated wheat farming in Roman Egypt, which probably managed about 1.67 t/ha and 0.6 t/cap. The spread of best practices across China after 1400, Perkins suggested, enormously increased aggregate output and even raised output per capita by replacing worse practices with better, but the best farmers in the 19th century were no more productive than the best farmers of the 14th century.

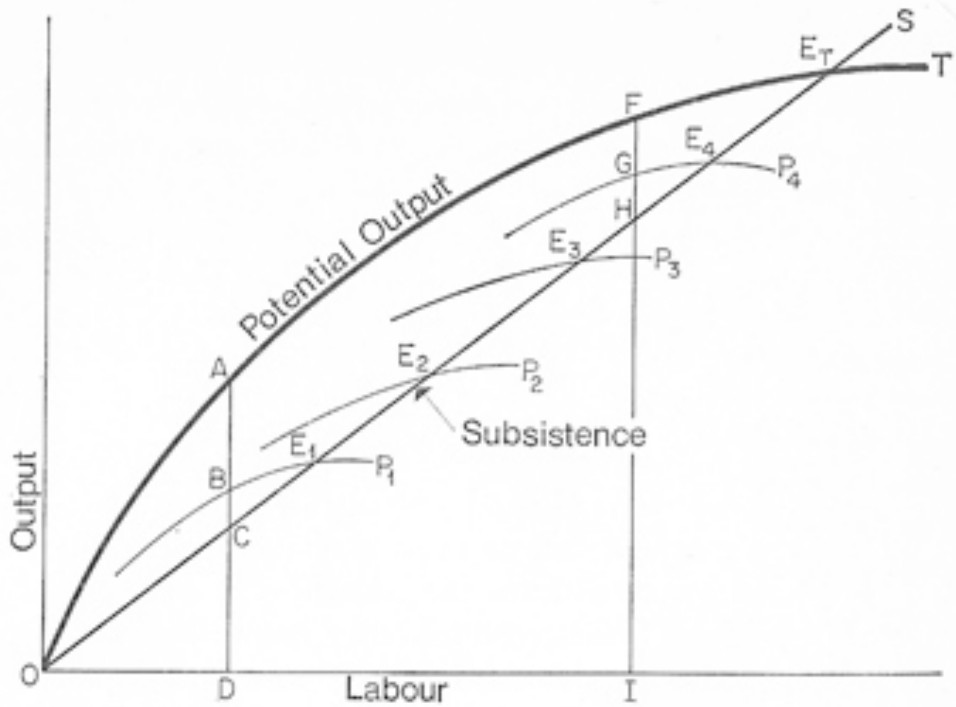


Figure 4. The high-level equilibrium trap in agriculture (after R. P. Sinha). This illustrates the effects of a discontinuity or quasi-ceiling in late traditional Chinese farm technology. OT shows potential output for a given input of labour with best pre-modern methods. OS shows the proportion of output needed for the subsistence of a given labour-force. With land constant, potential surplus (e.g., AC and FH) shrinks, first relatively, then absolutely, as labour-force grows. Actual surplus (e.g. BC and GH) depends on the level of 'practice', defined here as investment and organization (especially commercialization and land tenure). P_1, P_2, P_3, etc. show how at a given level falling returns per man as labour input grows create intermediate equilibria E_1, E_2, E_3, etc. At E_T further improvements in 'practice' are nil, and the ceiling on high-level pre-modern technology leads to a trap that can be broken out of only by using modern methods.

Graph 23. The "high-equilibrium trap" (after Elvin 1973)

Mark Elvin (1973) made a broader argument that after extraordinary increases in energy capture in Tang-Song times, China entered a "high-equilibrium trap" (Graph 17.23) in the 14th century, in which farming, industry, finance, and transport had reached the highest levels possible with traditional means. The only way to raise productivity, Elvin argued, was by leaping to a fossil-fuel economy; but because traditional techniques had reached such a peak of perfection, the kind of moves that led toward an industrial revolution in the West were impossible in the East, because in the short term they would actually have decreased output, which therefore ruled them out.

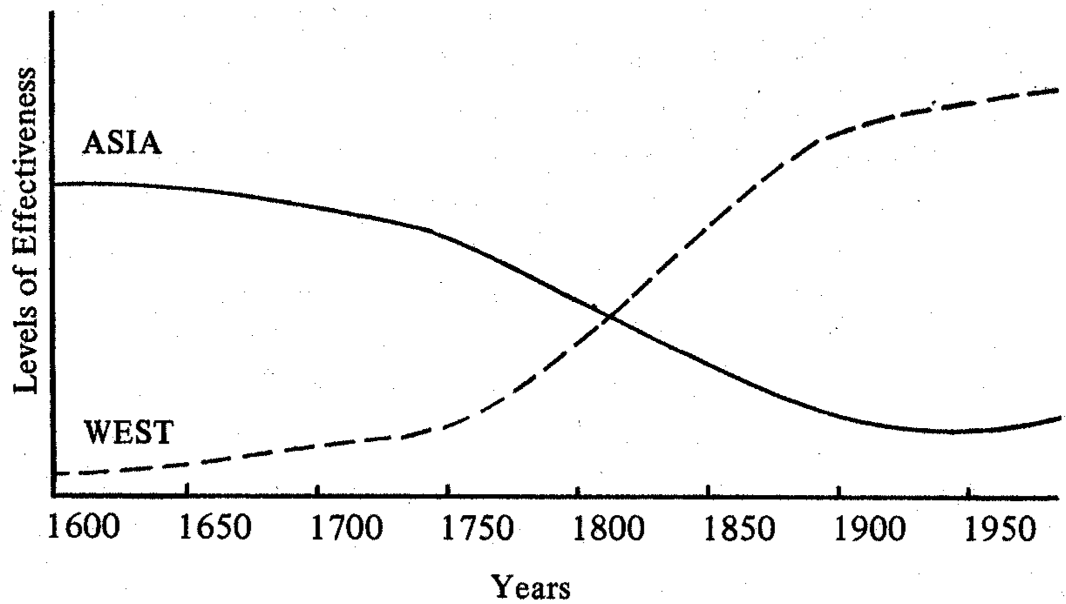
Both these approaches suggested that the Chinese economy stagnated for roughly 400 years, which matched with conventional Western long-term lock-in theories of a timeless, static China (see Wong 1997). In the same spirit, Angus Maddison (2007) suggested that between 1500 and 1820 Chinese GDP/cap was stable at around $600, just half the level in Britain in the year 1700, and, as noted in another section, Robert Allen suggests that Chinese urban unskilled wages were relatively stable between 1738 and 1900, and that Yangzi delta agricultural output declined slightly between 1600 and 1800.

Since the 1990s challenges from Kenneth Pomeranz and others have reopened the debate. My calculations suggest that in 1200 Song dynasty energy capture was quite similar to that in the Roman Empire (I suggested just over 30,000 kcal/cap/day) while in 1800 it was just slightly lower than contemporary Western scores (I suggested 36,000 kcal/cap/day). That would mean that energy capture per person increased by 15-20 percent between 1200 and 1700. Since so few historians have quantified their suggestions of rising living standards in early modern periods, it is hard to know whether this is closer to the Perkins/Elvin/Maddison/Allen view or the Pomeranz/Wong view.

However, it also seems unlikely that the increase between 1200 and 1700 was smooth. Recent studies of the Yangzi delta (in Smith and von Glahn 2003) suggest that some areas did experience much stability across these 500 years, but generally the 13th-14th century and (to perhaps a lesser degree) the 17th century were very traumatic. The 13th-14th century in particular saw massive population decline, destruction of cities, and collapse of trade. I do not know of detailed studies of specific sectors of the economy, but as a very approximate guess I suggest that after peaking just over 30,000 kcal/cap/day around 1200, energy capture fell by perhaps 5 percent (to say 30,000 kcal/cap/day in 1300 and 29,000 kcal/cap/day in 1400). That would lead to a rather faster period of recovery between 1400 and 1800 than in the traditional model, adding 20 percent to per capita energy capture across three centuries.

Future research may, however, smooth out these guesstimates, but the overall picture seems plausible: Eastern energy capture grew steadily—indeed, quickly by premodern standards—between 1200 and 1800; but Western energy capture grew much faster. Claims by historians such as

Andre Gunder Frank (1998) or Rhoads Murphey (1977) that an early-modern "decline of the East" was at least as important as an early-modern "rise of the West" in shaping 19th-century Western rule must be mistaken, unless we find evidence that before 1400 Eastern energy capture had risen to levels equivalent to those of the 19th-century West, and then fell—which is, in fact, exactly what Murphey's graph (which has no numbers on the *y*-axis) seems to show.

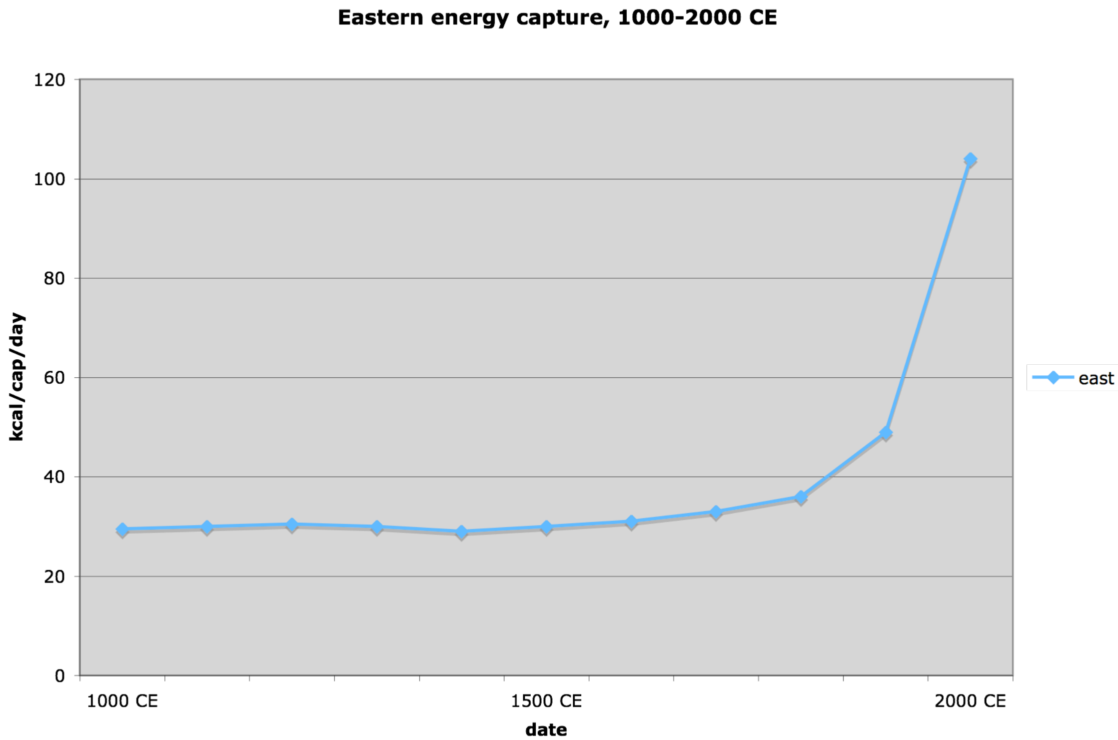


Graph 24. Rhoads' Murphey's (1977) impressionistic graph of the rise of the West and decline of the East, 1600-2000

Graph 25 shows my estimates for Eastern energy capture in the 2nd millennium CE.

[8.5.4] *Ancient China (200 BCE-200 CE)*

Ancient China under the Han dynasty (206 BCE-220 CE, conventionally divided into the Western/Former Han period [206 BCE-9 CE], the Wang Mang interregnum [9-23 CE, also sometimes called the Xin dynasty], and the Eastern/Later Han period [23-22] CE]) was a huge, complex, agrarian empire, broadly comparable to the contemporary Roman Empire (Adshead 2000: 4-21 usefully highlights the similarities). The first systematic comparisons of the Roman and Han Empires have only appeared recently, however (Scheidel 2009b; Mutschler and Mittag 2009 compare Roman and Han ideas of empire), and we currently badly need thorough comparisons of the archaeological data, preferably in quantitative form. Until such comparisons become available, the estimates in this section necessarily remain very impressionistic.



Graph 25. Eastern energy capture in the 2nd millennium CE

The most accessible surveys of the Han economy (Nishijima 1986; Ebrey 1986) provide few statistics, but textual sources and the qualitative accounts of Han archaeology do, however, allow for some tentative calculations. The most advanced Han agriculture was in northern China, particularly the Central Plain, and it sounds distinctly less advanced than the most productive Roman agriculture. Texts (Hsu 1980) and finds (Wang 1982) both suggest that even though the most sophisticated Chinese ironworking outstripped anything in the Roman Empire by the 1st century BCE, iron tools only spread slowly in 1st-millennium BCE Chinese farming. In 200 BCE bronze, wood, and even bone and shell tools may still have been more common than iron. The evidence for plows is debated, but metal-tipped plows seem only to have become common in Eastern Han times. Extensive use of plow oxen and brick-lined wells for irrigation also seem to be Eastern rather than Western Han features (Bray 1984). The literary sources also describe a series of improvements in farming instituted in Han times (Lewis 2007: 103-115), beginning with Zhao Guo's "alternating fields method" around 100 BCE, but it is hard to know how widely they were implemented. Many of the most productive techniques and machines may have been restricted to Eastern Han elite estates.

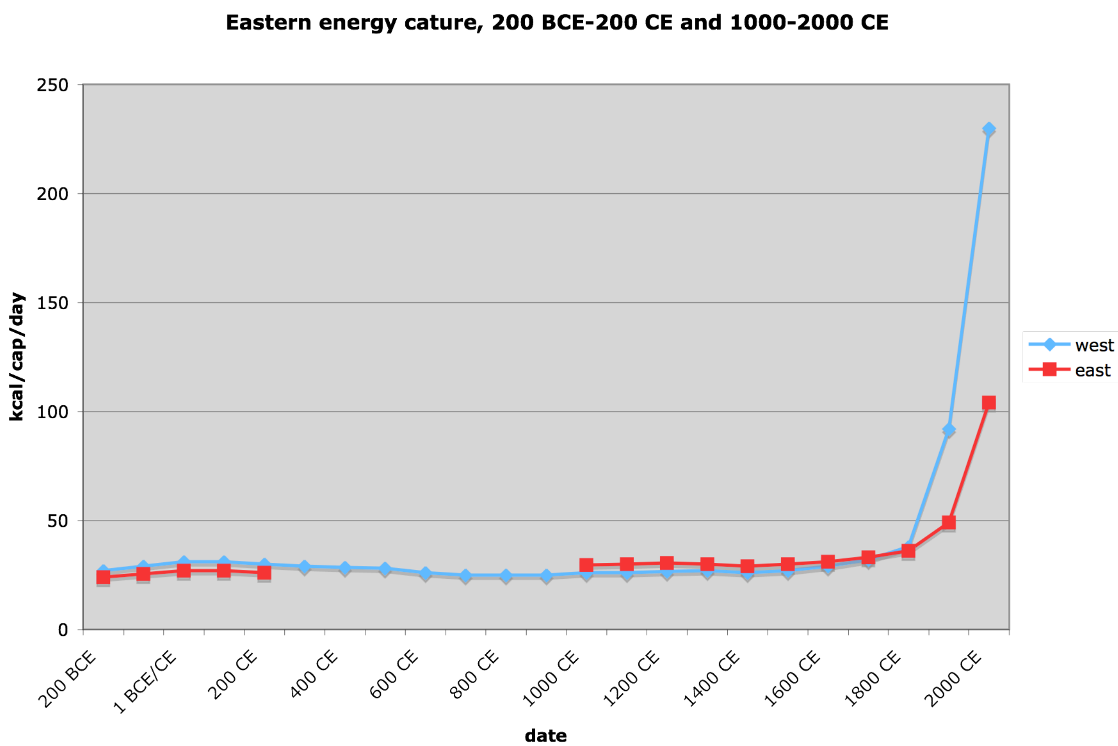
The impression—and it can be no more than that—is that Han farming was less productive than Roman, and particularly less productive than the advanced irrigation farming of the Nile Valley. Productivity certainly rose between 200 BCE and 100 CE, and Jia Sixie's *Essential Methods for the Common People* (Bray 2001), written in the 530s, shows that techniques (especially in rice farming) continued improving thereafter, even if organization and infrastructure broke down. The texts collected by Hsu (1980) suggest that agriculture in Han times was highly sophisticated but nevertheless less developed than Chinese farming would be in Jia's age, and probably also less developed than Roman farming. Systematic comparisons of Han and Roman skeletal evidence on stature and stable isotope analysis of nutrition would be extremely useful.

I know of no comprehensive finds catalogues that would let us directly compare the richness of material goods on settlement sites in the Roman and Han Empires. Han houses could certainly be quite sophisticated, judging from the clay models that survive (Guo 2010) and other evidence for layout (A. Boyd 1962; Thorp 1983), but generally the archaeological record suggests simpler, poorer structures in China than the brick and stone homes of the Roman Empire (Razeto 2008).

Scheidel (2009c) suggests that the Roman monetary supply was roughly twice the size of that in the Han Empire and that the largest Roman fortunes were also twice as big as the largest Han. These statistics probably correlate only loosely with per capita energy capture, but reinforce the impression that energy capture was higher in the ancient West than in the ancient East. Han energy capture also seems to have been lower than that in Song times; at least, there is no suggestion in the published Han evidence of anything to compare with Song levels of coal and iron use, road-building, technological invention, financial instruments, or long-distance trade. Trade with steppe nomads and Southeast Asia did increase sharply in Han times (Yü 1967; X. Liu 1988, 1996), and, as mentioned in *Why the West Rules—For Now* (Morris 2010: 270-75), by the 2nd century CE trade links probably existed between the Han and Roman Empires.

In the present state of the evidence, any actual numbers for Han energy capture must be speculative. I have suggested that the figure must be lower than the Western peak in Roman times (31,000 kcal/cap/day) and the Eastern peak in Song times (estimated at 30,500 kcal/cap/day). The archaeological and textual records also suggest that Han energy capture was higher than the West's would be at the trough of its post-Roman decline (25,000 kcal/cap/day in the 8th century CE), and much higher than it had been at its Late Bronze Age peak (21,500 kcal/cap/day around 1300 BCE).

I have therefore estimated a Han dynasty peak of 27,000 kcal/cap/day in the 1st century CE, with a slight decline (to 26,000 kcal/cap/day) by 200 CE as organization and infrastructure broke down. The increase during Western Han times seems to have been substantial; I suggest that energy capture rose more than 10 percent across that period, from 24,000 kcal/cap/day in 200 BCE to 25,500 kcal/cap/day in 100 BCE to the peak level of 27,000 kcal/cap/day in 1 BCE/CE and 100 CE. As noted above, these figures remain speculative, and should be corrected when better comparative archaeological data become available; however, the Han peak seems unlikely to have been below 25,000 kcal/cap/day or above 29,000 kcal/cap/day.



Graph 26. Ancient, medieval, and modern energy capture in the East, 200 BCE-200 CE and 1000-2000 CE

Graph 26 shows the estimates for Eastern energy capture in the periods 200 BCE-200 CE and 1000-2000 CE, and compares the curve with the Western scores for the past 2,200 years, showing the Western core's slight lead in antiquity and the Eastern core's slight lead in medieval and early-modern times, before the West's industrial takeoff.

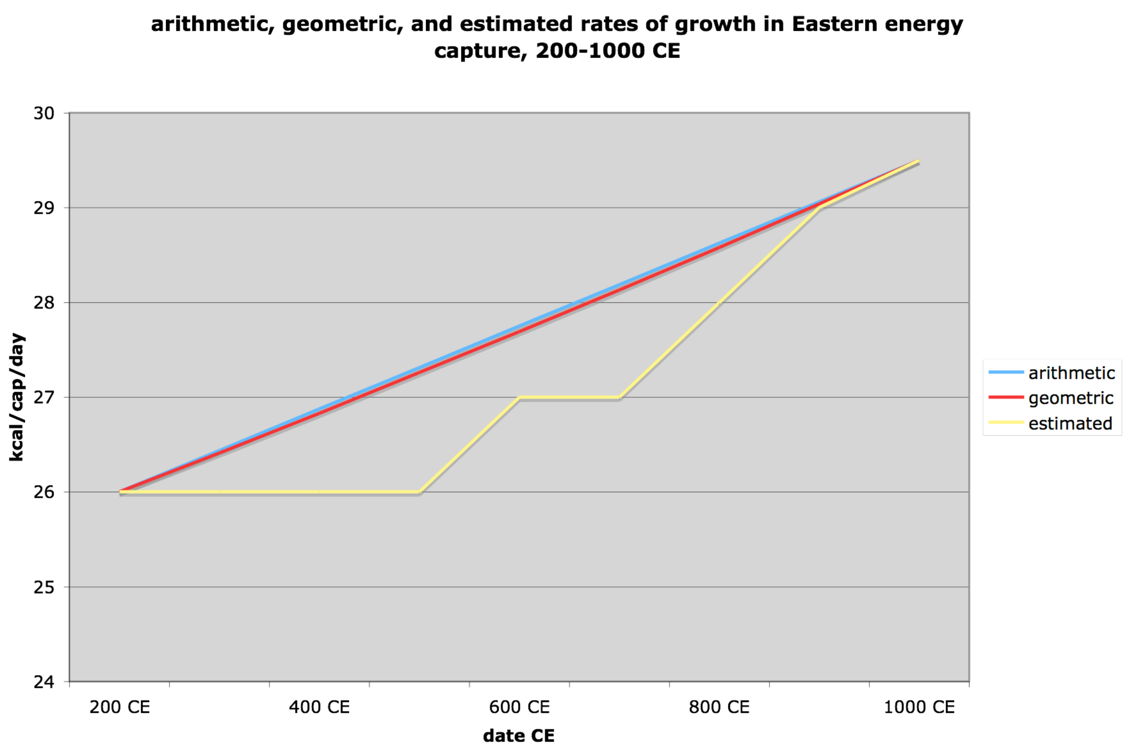
[8.5.5] *Between ancient and medieval (200-1000 CE)*

The history of energy capture in the "Period of Disunion" (220-589 CE) is even more obscure than that of Han times. Mark Lewis (2009a) has recently published an invaluable survey of the period and Al Dien (2007) has collected an equally helpful summary of the archaeological data, but there have been very few quantitative studies.

As in the West, basic economic infrastructures broke down after 200 CE (L-S. Yang 1947), even though agricultural technology probably improved. Jia Sixie's *Essential Methods for the Common People* (Bray 2001), written in northern China in 533/34, displays more detailed knowledge of dry-grain farming than any Han text, and also reveals deep knowledge of rice agriculture being practiced in southern China. It seems that best practices in rice farming steadily spread south of the Yangzi from the 3rd century CE onward, raising yields very significantly by the end of the 1st millennium (Bray 1984, 1986).

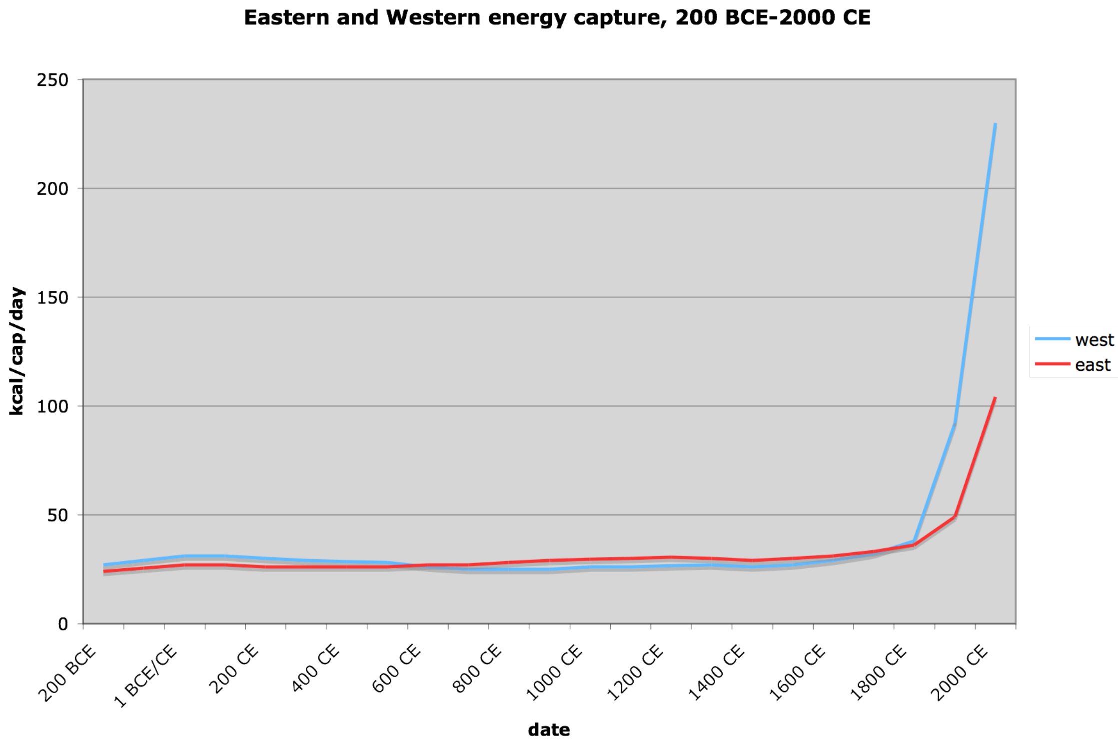
Economic infrastructure also improved, with paddleboats appearing on the Yangzi in the 5th century, watermills at Buddhist monasteries being used by many households (Twitchett 1957a), and regional specialties like tea being traded widely. The state intervened drastically in land ownership, most famously in the "Equal Field System" (Twitchett 1959, 1961a; Xiong 1999), but this seems to have helped keep farmers on the land despite the upheavals of the 4th-6th centuries. Before the reunification of China in 589 and the opening of the Grand Canal in the 7th century the post-Han economic recovery was largely restricted to the new rice frontier in the South (e.g., S. Liu 2001), while commerce declined in the North to the point that coinage largely disappeared; but by 650 an empire-wide economic revival was under way. Irrigation came into much wider use (Twitchett 1957b, 1961b), and enormous public markets are documented at Chang'an and other large cities (Twitchett 1966). The collapse of state power after An Lushan's revolt in 755 weakened the Tang dynasty's control over the economy, but any losses involved seem to have been outweighed (particularly in the South) by the gains merchants made from being freed from bureaucratic interference (Twitchett 1968).

Most historians seem to agree that China saw rapid (by premodern standards) economic growth between 600 and 1000 and was economically more advanced than the West in this period (e.g., Adshead 2004, Lewis 2009b). Elite houses in Tang times were at least as impressive as those of the Han era (H. Yang 2003), and Buddhist (Kieschnick 2003) and court art flourished (Karetzky 1996), but medieval Chinese archaeology has so far concentrated rather heavily on art history and architecture, and we have few data from which to quantify what these changes meant for energy capture at the individual level. If my estimates of energy capture at 26,000 kcal/cap/day in 200 CE and just under 30,000 kcal/cap/day in 1000 CE are roughly correct, then the seven centuries in between saw a roughly 15 percent increase. The impression created by the sources cited above is that most of this increase came between 700 and 900; I have consequently estimated that energy capture remained fairly flat at 26,000 kcal/cap/day between 200 and 500 CE, then rose to 27,000 kcal/cap/day in 600, rose again to 28,000 kcal/cap/day in 800, and 29,000 kcal/cap/day in 900. Graph 27 shows these estimated scores and the scores if energy capture actually increased steadily across the period 200-1000 (either arithmetically or geometrically). The differences are very small.



Graph 27. Three methods of estimating Eastern energy capture 200-1000 CE

Graph 28 shows my estimates for East and West for the entire period since 200 BCE. According to these calculations, Eastern energy capture overtook Western for the first time in history in 563; otherwise, though, the history of energy capture was uneventful in the two millennia before 1800 CE. At both the Eastern and the Western end of Eurasia, large empires pressed against the upper limits of what was possible in an organic economy (cf. Wrigley 1988), but could not break through. This is the reality that that underlay the common perception of history as cyclical in Eurasian cultures in these years; up to a point, Eurasian elites were correct in thinking that nothing changed very much.



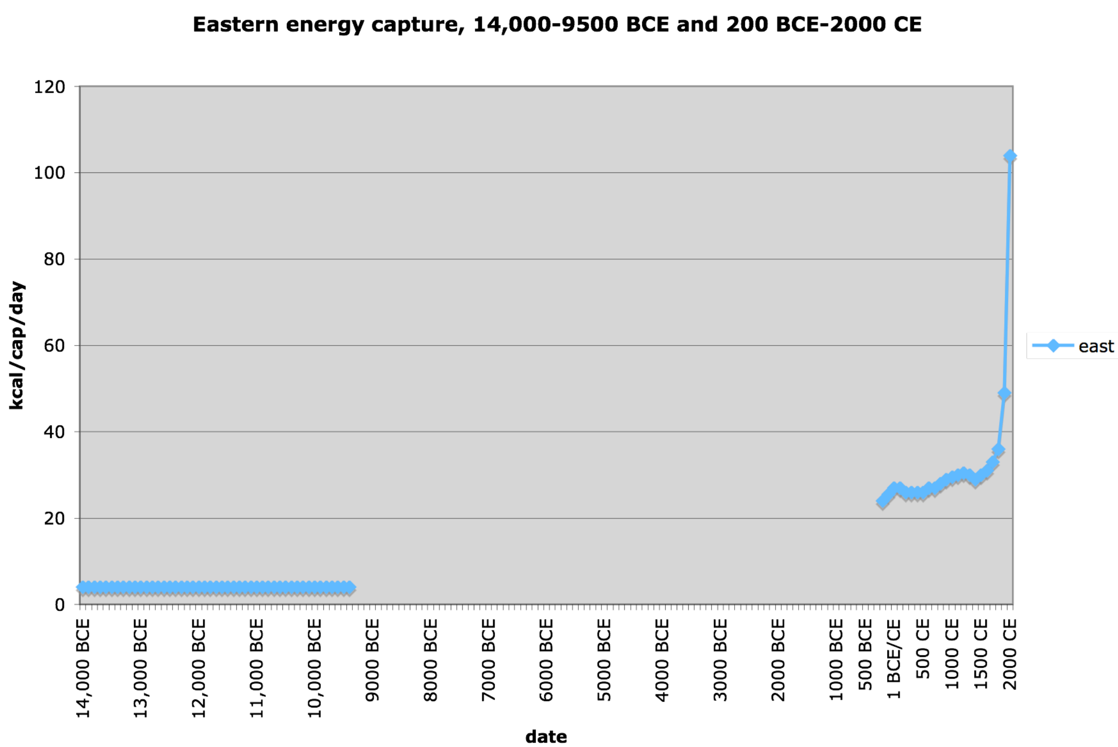
Graph 28. Eastern and Western energy capture, 200 BCE-2000 CE

[8.5.6] *Late- and post-Ice Age hunter-gatherers (c. 14,000 BCE–9500 BCE)*
My estimates of late- and post-ice age energy capture in the East depend heavily on the same research in primate energetics and human evolution as the estimates for the West. *Homo sapiens* in East Asia must have been capturing somewhere around 4,000 kcal/cap/day in 14,000 BCE, otherwise they would have died out; and if they had captured significantly more—even 5,000 kcal/cap/day—we would be able to see it in the archaeological record, in the form of more elaborate buildings, material culture, or expensive food calories. As it is, we see remarkably little change in the archaeological record for nearly 5,000 years.

In the Western core, energy capture was already increasing before the Ice Age ended, but in the East structural remains are completely lacking from sites before 9000 BCE (e.g., Longwangcan: Shaanxi Institute of Archaeology 2008). There is some evidence for increasing exploitation of animal carcasses around 25kya (Zhang et al. 2010), and crude, handmade and low-fired pottery—the world's earliest, dating around 16,000 BCE—comes from Yuchanyan Cave in South China (Boaretto et al. 2009). By 14,000 BCE pottery was also being made in North China and the Russian Far East (Kuzmin 2006). The invention of pottery probably means that new kinds of food, requiring boiling, were being eaten, and wild rice (in the South) and wild millet (in the North) seem likely candidates.

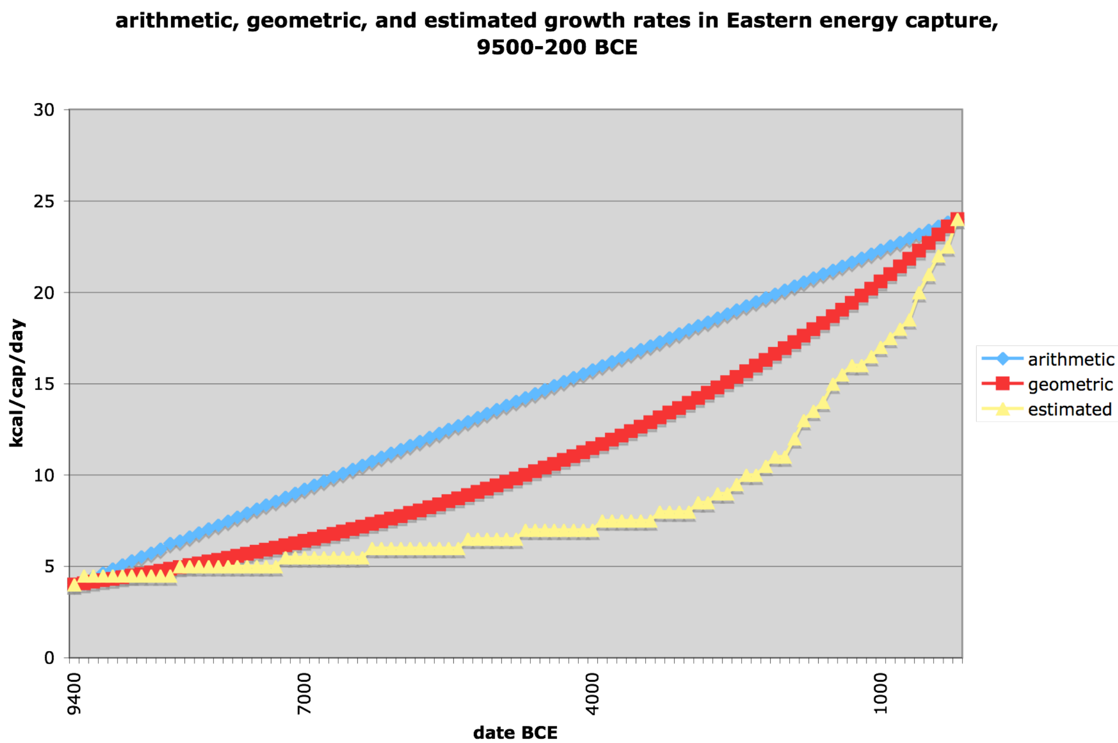
However, unlike the situation in the Western core, where rye seeds become plumper at Abu Hureyra by 11,000 BCE (Hillman et al. 2001), there is little good evidence for increasing per capita capture of food calories between 14,000 BCE and 9500 BCE (e.g., Diaotonghuan Cave: Zhijun 1998; Yuchanyan: Prendergast et al. 2009). At Diaotonghuan wild rice was being gathered and brought back to the cave by 12,000 BCE, well before the Younger Dryas cold period of 10,800-9600 BCE, but seems to have disappeared during this mini-ice age, only returning after 9600. There is as yet no evidence for cultivation of rice or any other plant before the Younger Dryas. There must have been other changes across these millennia, of course, but they seem to have been cyclical and on a scale too small to measure. I therefore estimate energy capture at 4,000 kcal/cap/day for the entire period 14,000-9400 BCE.

[8.5.7] *From foragers to imperialists (9500-200 BCE)*



Graph 29. Eastern energy capture, 14,000-9500 BCE and 200 BCE-2000 CE

As Graph 29 makes clear, there is a wide gap to fill between the reasonably secure estimate of energy capture for post-ice age hunter-gatherers (4,000 kcal/cap/day in 14,000-9500 BCE to the next estimate, of 24,000 kcal/cap/day under the Western Han dynasty in 200 BCE. We could simply assume a steady growth rate, either arithmetic or geometric, across these 7,300 years, but the combination of the actual archaeological and textual data, comparanda from economic anthropology, and comparisons with the scores after 200 BCE allow us to be more precise (Graph 30).



Graph 30. Three ways of estimating Eastern energy capture, 9500-200 BCE

I will divide the period into three phases, first briefly describing some of the developments in each phase in general terms and then trying to quantify what these changes meant for energy capture.

(a) Foragers and farmers, 9500-2500 BCE

Archaeologists working in East Asia have often been eager to push the dates of the origins of agricultural as far back into the past as possible. The stone grinders and rollers found at north Chinese sites such as Nanzhuangtou and Hutouling in Hebei as early as 9000/8500 BCE, for instance, have sometimes been treated as evidence of domestication of millet. Analysis of starch residues on ice-age grinders dating back to 23,000 BCE in Europe (Aranguren et al. 2007), however, has shown that they were used to grind wild plants into a paste, to make a kind of pre-agricultural porridge or bread, and studies of starches from 9th-millennium BCE grindstones excavated recently at Donghulin suggests that they too were used for wild plants, in this case acorns (L. Liu et al., forthcoming).

The direct physical evidence for domesticated plants in East Asia has become the subject of intense debate in the last five years. Since the 1980s it had been a commonplace in Chinese archaeology that the rice husks used as temper in pottery at Pengtoushan in the Yangzi valley around 7000 BCE must have been domesticated, and more recently Jiang and Liu (2006) suggested that husk impressions and phytoliths from Shangshan in the Yangzi delta and Jiahu in the Huai valley confirmed the domestication of rice by 7000 BCE.

Comparing the evidence and arguments in China with debates over the beginnings of agriculture in Southwest Asia, however, Fuller et al. (2007) suggested that there must have been a long period of cultivation of rice before fully domesticated forms evolved. They argued that Jiang and Liu had been misled by the presence of immature spikelets, which would be very common among gathered wild rice, and that the finds from Shangshan and Jiahu are wild. Fuller et al. concluded that cultivation of rice only got seriously under way around 5000 BCE, perhaps in response to a decline in oak cover and with it shortages of the previously important acorns. Fully domesticated rice, they suggested, evolved only around 4000 BCE. They suggested that the domestication of millet in northern China actually preceded that of rice in the South, with clear evidence for cultivated millet by 5500 BCE and domesticated plants by 4500.

Heated exchanges have followed (L. Liu et al. 2007a, 2007b; Fuller and Qin 2008; Fuller et al. 2008). As so often, there seem to be valid points on both sides of the debate: if the cultivation and domestication of rice began as late as Fuller insists, some of the features of its dispersal across China would be hard to explain; yet if cultivation and domestication began as early as Liu insists, the continuing absence of large, unambiguous samples would be equally hard to explain. Further work will certainly resolve the point, and I suspect it will confirm Fuller's model of a long, drawn-out period of cultivation, while probably also vindicating the traditional view that much of the rice found at the waterlogged 5th-millennium site of Hemudu was domesticated, and that cultivated rice was already present at Jiahu, Diaotonghuan, and Pengtoushan in the 7th millennium.

Our picture of the agricultural revolution in the Eastern core in China is coming to look increasingly like that of the same phenomenon in the Western core in Southwest Asia, but beginning approximately 2,000 years later. Just as in the West, it seems that the decisive steps happened not in the great river valleys but in "hilly flanks" surrounding them (X. Liu et al. 2009), that the dispersal took millennia and combined emulation and migration (Chi and Hung 2010), and that it was accompanied by an equally lengthy "secondary products revolution."

This can best be seen in China in the evolution of agricultural tools. At 6th-millennium Banpo, for instance, harvesting knives made up less than one-third of the total tool assemblage, while at 5th-millennium Miaodigou they had risen to more than half. At Banpo, ineffective pottery blades outnumbered stone blades more than 2:1; at Miaodigou, stone blades outnumbered pottery. At Banpo, axes (necessary for felling trees in slash-and-burn agriculture) outnumbered shovels (necessary for turning the soil in already-cleared fields) more than 5:1; at Miaodigou, spades outnumbered axes more than 4:1. The blades of Miaodigou spades were also typically 50 percent longer (30 cm vs. 20 cm) than those from Banpo, suggesting that 5th-millennium farmers were turning soil more deeply, improving aeration, than those of the 6th millennium (Zhang 2005: 60-64).

Other categories of evidence support this picture of a drawn-out secondary products revolution, such as new stable isotopic analyses from North China showing that millet only became a major food source after 5000 (Hu et al. 2006, 2008), and evidence for the slow domestication of animals in the Yangzi valley (Jing et al. 2008).

The great difference between East and West, however, is that cultivation and domestication seem to have begun in the Western core some 2,000 years earlier than in the Eastern core. Even if we pass over the cultivated rye seeds from Abu Hureyra dating around 11,000-10,500 BCE (which apparently precede the Younger Dryas), by 9500 BCE, immediately after the end of the Younger Dryas, cultivated barley and wheat are unmistakable in the Western core. On the present state of the evidence, it is hard to see cultivated rice or millet in the East before about 7500 BCE (and even later than this is Fuller is correct). Fully domesticated wheat and barley were firmly established in the West's Hilly Flanks by 7500 BCE, while domesticated millet was not the norm in the East till 5500 and rice not till 4500 (or 4000, according to Fuller). The secondary products revolution, largely complete in the West by 4000 BCE, was still unfolding in the East in the 3rd millennium BCE. Not until 2500 BCE, for instance, do we find really convincing Eastern evidence of classic agrarian gender structures, with men associated with outdoor activities and women with indoors (Liu 2004: 35-38).

As in the West, the Eastern increase in aggregate capture of food calories went along with great population growth and a slow but impressive increase in the per capita capture of non-food calories (Liu 2004). The earliest houses known date around 8000 BCE, at Shangshan in the Yangzi delta (Jiang and Liu 2006); earlier sites have produced only hearths. House sizes steadily increased, from the round, semi-subterranean huts averaging just 4-6 m^2 at 7th-millennium Jiahu to the square, above-ground buildings covering 30-40 m^2 at 4th-millennium Dahecun. The largest structure at 7th-millennium Jiahu covered 10 m^2, while 4th-millennium Dadiwan had "palaces" covering 150 m^2 and 290 m^2, counting just the roofed space (Liu 2004: 74-95). The contents of houses also increased, slowly until the 3rd millennium, but then jumping sharply (Liu 2004: 39-46).

(b) Archaic states (c. 2500-800 BCE)

The rate of increase in energy capture accelerated after 2500 BCE, and particularly after 2000, with the emergence of more complex societies. As in the West, there are no large-scale systematic collections and comparisons of skeletal data to document directly the impact of archaic states on the human body, but there are other indications of change.

One is the spread of rice agriculture in northern China, particularly after about 2300 BCE, and the huge increase in animal bones from settlements in the late 3rd and 2nd millennia. By 2000 BCE domesticated pigs regularly make up two-thirds of the domestic faunal assemblages (Shao 2005: 90). The textual record also speaks of various later reforms in the organization of agriculture. *Mencius* 3/1 (a philosophical text composed around 300 BCE) speaks of the "Well Field System," supposedly instituted under the Western Zhou dynasty in the early 1st millennium BCE, although Mencius' account must be an idealized version of a much messier reality (Hsu 1965: 107-108). Historians often describe this land-tenure regime as a kind of feudalism, although this does not seem entirely appropriate (F. Li 2003).

Overall, Eastern agriculture seems to have remained much less productive (per unit of labor or land) than contemporary Western practices. A few copper objects (mostly ornaments) are known from 3rd-millennium sites, but there are very few examples of metal agricultural tools before 800 BCE. Wood, stone, bone, and shell remained overwhelmingly the most important materials in agriculture down to 800 BCE, and until better evidence appears, we have to conclude that agricultural output in the Eastern archaic states rose more slowly than that in the irrigated farming systems of the Western archaic states in Mesopotamia and Egypt.

Non-food energy capture, however, does seem to have increased strongly between 2500 and 800 BCE. Our picture is limited by archaeologists' surprising lack of interest in post-Neolithic settlements in

China (caused by an archaeological focus on elite tombs and monuments rather than by scarcity of actual remains). The few finds do show that by 800 BCE the size and quality of houses had improved. Pit houses continued to be built, but more people lived above ground, at least sometimes in substantial, rectangular houses with trenched foundations, rammed earth or mudbrick walls, and lime-plastered floors and wall skirting. Some houses had painted decoration, while others were organized around spacious courtyards, and finds of waterlogged carpentry in tombs show that joinery techniques improved drastically. The chronology of these developments remains unclear, but in broad terms we can be confident that housing standards rose significantly between the late 3rd and early 1st millennium BCE (Shao 2005: 91; von Falkenhausen 2006: 410-11, n. 30).

The quantity and quality of household goods also rose. Potters were regularly using fast wheels in the 2nd millennium, and silk, lacquer, and jade became more common. The first copper objects appear around 3000 BCE, almost certainly stimulated by knowledge of Western metallurgy brought over the steppes (Roberts et al. 2009). Metal seems to have been very rare indeed until the early 2nd millennium BCE, when gigantic foundries appeared at Erlitou, Zhengzhou, and Anyang, casting weapons, some craft tools, but above all ritual vessels. Well-preserved mines at Tongling attest to the scale of Chinese metallurgy as early as 1600 BCE (Liu and Chen 2003).

The lack of good household archaeology means that we know rather little about the everyday use of metals, though grave goods and hoards seem to imply that bronze vessels did spread some way down the social scale by 800 BCE. At the elite level, metal use was enormous; the largest known ritual vessel, the 12th-century Simu Wu square *ding* (probably looted from a royal tomb at Anyang), used nearly one ton of bronze (Lu and Yan 2005: 158-60). After the Shang/Zhou transition in 1046 BCE the number of inscribed bronze vessels explodes, probably testifying the to the emergence of a very wealthy aristocracy (Rawson 1999; von Falkenhausen 2006). Archaeologists have also identified a "ritual revolution" in the elite use of funerary bronzes in the 9th century (Rawson 1988), which seems to have coincided with great advances in bronzeworking, including use of the lost-wax method and welding (Li Xueqin 1985: 272-76; Lu 2005: 205-210).

Elite monuments also expanded enormously after 2500 BCE. The largest sites of the late 3rd millennium (sometimes covering 200-300 ha) began to have stamped earth platforms that were often 2m+ thick. The grandest of all these sites, at Taosi (Liu 2004: 108-111), had a palatial enclosure covering 5 ha as early as 2600 BCE; by 2300 it was protected by fortification walls 9 m thick and boasted a great circular monument (Shanxi Fieldwork Team 2005) and a palace with painted walls.

Beginning around 1900 BCE much bigger palaces were constructed at the probable Xia-Shang dynastic capitals of Erlitou, Zhengzhou, and Erlitou, and the 13th- to 11th-century Shang royal tombs at Anyang, although looted, are impressive by any standards (Chang 1980; Thorp 2006). The Western Zhou palaces excavated to date are less grandiose than their Shang predecessors (e.g., Lu and Yan 2005: 183-87), although the remains from the capital at Feng are still very substantial. Wealthy burials also proliferated after 1046 (von Falkenhausen 2006; F. Li 2006, with references). The scale of elite ostentation and energy capture may have leveled off between 1000 and 800 BCE, but was nevertheless far higher than in 2500 BCE.

As in the West, the era of archaic states saw the first unambiguous evidence for regional collapses, most obviously with the fall of Taosi and the breakdown of the Shandong complex societies around 2300 BCE. Like the 2200 BCE and 1750 BCE collapses in the West, though, the Taosi/Shandong decline had no obvious impact on energy capture, at least when measured on the coarse grain used here.

(c) The Spring-and-Autumn/Warring States period (800-200 BCE)

The East experienced nothing like the catastrophic 1200 BCE collapse in the West, which dragged the core's energy capture down for centuries. Eastern energy capture, by contrast, rose faster and faster. As in the era of archaic states we are handicapped by the lack of syntheses of skeletal data and the scarcity of household excavations, but again the evidence is adequate to establish a general picture.

The literary sources attest further changes in land tenure, particularly a shift toward private landholdings in the possession of legally free peasants, taxed by the state, replacing the dependent peasantry working land for their lords. The first clear sign of this is a tax on yields in the state of Lu in 594 BCE, and by the 3rd century BCE the shift to freehold was probably complete (Hsu 1965: 108-109). This change in property rights probably encouraged more investment by the farmers themselves (Zhao, forthcoming); if so, higher yields were the likely outcome. It also went along with the development of a sophisticated literature on the theory and methods of farming, beginning with Li Kui in the state of Wei around 440 BCE (Lewis 1999: 604-605).

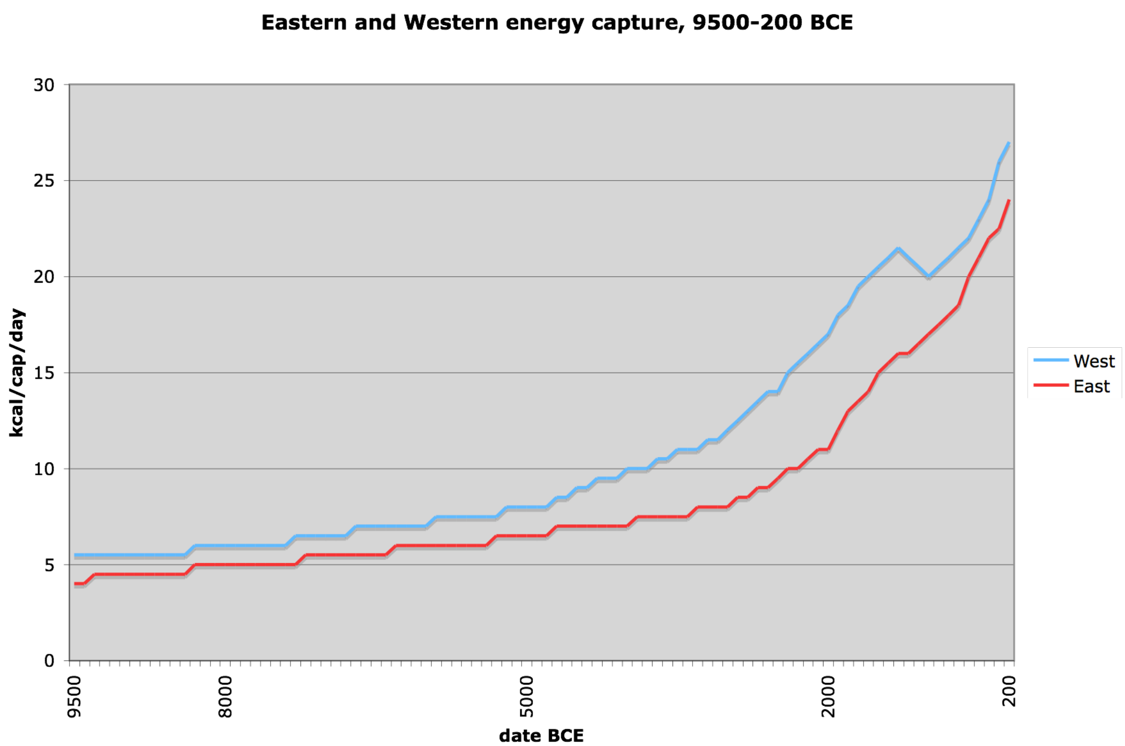
Textual evidence for multi-cropping seems to go along with the new property regime. By 200 BCE it was apparently normal to rotate two crops (wheat and millet in northern China, millet and rice in the South), with occasional planting of legumes, potentially producing three crops every two years (Hsu 1980: 81-88). Some historians also argue from the spread of names based on "ox" that draft animals also became important (at least among the elite) in the mid-1st millennium BCE (e.g., Hsu 1999: 578). We are on more certain ground, however, with the textual evidence for massive state involvement in irrigation projects beginning with the magistrate Ximen Bao in the state of Wei in the 430s. All the Warring States invested heavily in canals to improve agricultural output, culminating in Li Bing's massive project for the state of Qin in newly conquered Sichuan around 300 BCE (Sage 1992; Needham 1971: 288-96).

Metal tools probably first began to be used on significant scales only after 800 BCE. Li Xueqin (1985: 284-94) and Donald Wagner (1993) have suggested that bronze tools became more and more important in the lower Yangzi area between 800 and 500 BCE, but some archaeologists remain skeptical (e.g., von Falkenhausen 2006: 409-410, n. 29). By 500 BCE, however, iron was in use in China (probably, like bronze technology, ironworking was initially transmitted from the West across the steppes). Chinese smiths made rapid progress, making true steel in the 6th century and cast iron in the 5th (Western smiths would not master this technology until the 14th century CE). By 200 BCE iron weapons had begun to replace bronze and iron tools were definitely becoming commoner (Hsu 1980; Bray 1984; Wagner 1993). Bronze industries continued to flourish, though, with a 6th-century mine at Tonglüshan displaying extraordinary sophisticated construction in its timber-lined shafts (von Falkenhausen 1999: 539) and a huge, equally impressive foundry at Houma (Li Xiating et al. 1996).

Commerce also accelerated in this period. Beginning with Zang Wenzhong of the state of Lu in 625 BCE, ministers moved to abolish customs posts within their states. Vassal states had to give guarantees not to interfere with traders, and water transport became increasingly easy (Hsu 1965: 117-18). Independent of developments in the West, Chinese traders began minting and using bronze coins in the 5th century (Li Xueqin 1985: 372-77). By 200 BCE, millions were in circulation (Scheidel 2009c). Archaeologists in China have not yet quantified shipwrecks, animal bones, inscriptions, and lead pollution in the same way as has been done in the West, but a great increase in trade between 800 and 200 BCE nonetheless seems very clear.

(d) Calculating the scores

Graph 30 on p. 96 above shows three different ways of filling the gap in energy capture estimates between 9500 and 200 BCE, by simply assuming steady increases at arithmetic or geometric scales, versus making estimates based on the actual evidence. Arithmetic increases seem highly unlikely: the upper line in Graph 30 would mean that the increase in energy capture between the foundation of Jiahu around 7000 BCE and that of Hemudu around 5000 BCE was as large as that between the destruction of Taosi around 2300 BCE and the Qin irrigation of Sichuan around 300 BCE. That cannot be correct. The rise in energy capture was exponential, with the exponent increasing through time.



Graph 31. Eastern and Western energy capture, 9500-200 BCE

All the challenges that applied to converting archaeological data into consumption levels in the West also apply in the East, but comparing the Eastern and Western finds suggests that the East in fact followed a very similar trajectory to the West. The major difference was that the East started down the path of cultivation and domestication about 2,000 years behind the West, and its energy capture consequently ran behind the West's. Initially, in the foraging-to-farming era discussed in section (a) above, the gap seems to have stayed at about 2,000 years. I suggest that Eastern energy capture increased by roughly 50 percent, from 4,000 to 6,000 kcal/cap/day, between 9500 and 6000 BCE, and by 2500 BCE had risen by another 50 percent, to 9,000 kcal/cap/day, as the secondary products revolution ran its course. Eastern energy capture at this point, the age when Egyptians were building the great pyramids, seems to have been comparable to levels in the Western core around 4500 BCE, the age when the West's first large towns, like Tell Brak and Susa, were appearing (Graph 31).

After 2500 BCE, though, Eastern energy capture grew much faster. With such poor Eastern data we can only speak in terms of general impressions, but it seems to me that by 2000 BCE, on the eve of Erlitou's take-off, Eastern energy capture must have been roughly comparable with where the Western core had been around 3500 BCE, in the age of Susa and one the eve of Uruk's expansion (i.e., 11,000 kcal/cap/day). In 1500 BCE, when the Shang were building Zhengzhou, Eastern energy capture seems to me comparable with the Western level around 2400 BCE, in the era of the Royal Cemetery of Ur and Egypt's great pyramids (14,000 kcal/cap/day). By 1000 BCE, when the Zhou displaced the Shang, Eastern energy capture strikes me as being comparable with that of the Western core 1,000 years before, in the post-crisis recovery that replaced Egypt's Old Kingdom with the Middle Kingdom and Mesopotamia's Ur III Empire with the Akkadian city-states (17,000 kcal/cap/day). By 500 BCE, though, the West's collapse around 1200 BCE and slow recovery had sharply narrowed the gap. I would suggest that by 500 BCE, Eastern energy capture was comparable to the West's around 800 BCE, as the Assyrian Empire was approaching the great crisis that drove it to shift toward high-end institutions (i.e., 21,000 kcal/cap/day)—which was also, of course, the level that the West had reached around 1400 BCE, half a century before Akhenaten and Nefertiti began their bizarre experiment at Amarna.

These estimates will of course need to be tested against better evidence (Western as well as Eastern), and can be nothing more than conjectures, but if they are in approximately the right range, they mean that after roughly doubling in 6,000 years between about 9500 and 3500 BCE, Eastern energy capture doubled again in the 2,000 years between 3300 and 1300 BCE, and then rose another 50 percent in the 1,100 years between 1300 and 200 BCE.

The Western collapse around 1200 BCE was the main factor in shrinking the East-West gap to 300 years by 200 BCE, but the convergence had already begun long before then. In the 1,000 years between 2200 and 1200 BCE, in fact, Western energy capture increased by just 31 percent, but the East's rose by 52 percent. Why this happened is not entirely clear, although it does now seem certain that the East learned bronze technology from the West via the agency of travelers over the steppes (Roberts et al. 2009). Whether this alone explains the East's catch-up, or whether the

Central Asian travelers so well preserved as the Tarim Basin mummies (Mallory and Mair 2008) transferred more technologies from West to East, or whether as yet unidentified factors caused Eastern society to evolve faster than Western in the archaic states phase remains to be established.

[8.6] *Energy capture: discussion*

Graph 1 on p. 19 above, showing the shape of energy capture across the last 16,000 years, is the backbone of my argument in *Why the West Rules—For Now*. The other dimensions of the social development index—organization (measured through the proxy of city size), war-making capacity, and information technology—are, after all, simply ways of *using* energy; and although measuring energy capture alone would not cover the full spectrum of ideas encapsulated in social development (Morris 2010: 143-50, 625-26), energy necessarily must be the central plank in any index. I have therefore discussed the evidence for energy capture in more detail than that for the other three traits.

Clearly, much work remains to be done. Our evidence for energy capture is patchy and imprecise. There are generally more data to work with in Western history than in Eastern, and where quantifiable evidence does exist, as in much of prehistoric archaeology, scholars working on the West have usually produced more syntheses of the results than those working on the East. In particular, scholars of the West have done more household archaeology and more research on real wages.

As the evidence base improves, new findings will resolve some of the questions reached here. For instance, in time we may be able to say with more confidence whether the Roman peak in Western energy capture came in the 1st century BCE or the 1st or 2nd century CE, and whether it really was higher than the Song peak in the East (and whether that really came in the 12th century). We should also be able to document whether there really was a decline in energy capture in East and West alike in the early-to-mid 1st millennium CE, whether the Western crisis around 1200 BCE really did drive down energy capture (as I suggest it did), and whether the Western crisis around 2200 BCE and the Eastern one around 2300 BCE also drove down energy capture (as I suggest they did not). Better evidence will inevitably strengthen some of the conclusions I have reached and weaken others.

The overall pattern, though, seems to me to be grounded fairly firmly in evidence, even if there is room to dispute any specific score. Energy capture at the end of the last Ice Age was very low, not much above 4,000 kcal/cap/day, and rose extremely slowly. There were gains in food calories, but as Malthus saw 200 years ago, these were normally converted into extra bodies, which consumed the gains and kept most people's food consumption around 2,000 kcal/cap/day. But as Malthus also saw, there were more substantial gains in non-food calories, and these accumulated over time. Total (food + non-food) energy capture consequently grew exponentially rather than arithmetically, and the exponent increased over time.

In both East and West, we see knees in the curve around the time of the beginnings of cultivation (c. 9500 BCE in the West and 7500 BCE in the East), the beginnings of domestication (c. 7500 BCE in the West and 5500 BCE in the East), the rise of archaic states (c. 3500 BCE in the West and 2000 BCE in the East), the creation of empires (c. 750 BCE in the West and 300 BCE in the East), and above all with the rise of fossil-fuel industries (c. 1800 CE in the West and 1900 CE in the East). For roughly 2,000 years, between the zenith of the great ancient empires and the industrial revolution, energy capture was trapped under what I have called a "hard ceiling", a little over 30,000 kcal/cap/day. This, I suggested, marks the limits of the possible in agrarian societies. It also largely explains the pervasive sense in the elite writings that survive from ancient and medieval times that humanity had reached its peak, that history was cyclical, and that the best times lay in the past—just as the explosive growth in Western energy capture since 1700 CE largely explains the optimism of so many European thinkers in the 18th and 19th centuries and Americans in the 20th and 21st.

9 Organization

[9.1] *Methods, assumptions, and sources*

I used organization as my main example of how I calculated social development scores in *Why the West Rules—For Now* (Morris 2010: 148-53, 631-32), so my comments here will be brief. A long tradition of research in archaeology and anthropology (e.g., Carneiro 1967; Forge 1972; Fletcher 1995) and economics (De Long and Shleifer 1993) has demonstrated the strong relationships between the size of the largest settlements within a society and the complexity of its social organization. The correlation is far from perfect, but it works well enough at the coarse-grained level of an index of social development spanning 16,000 years.

City size also has the great advantage of being, in principle, conceptually simple: all we need to do is to establish the size of the largest settlements in East and West at each point in the past and calculate what fraction that represents of the world's largest city in 2000 CE. Opinions vary among demographers on the latter, depending on definitions of urban boundaries and the reliability of census data; to establish a fairly uncontroversial baseline, I simply took the *Economist Pocket World in Figures*' estimate that Tokyo was the world's biggest city in 2000, with a population of 26.4 million, and that New York was the biggest city in the Western core, with 16.7 million people (*Economist* 2004: 20). There are plenty of other estimates I could have used, but no reliable figures seem to depart very far from this number.

This starting point means that the East scores the full 250 points for organization in 2000 CE, and that that a population of 106,800 scores 1 point. New York's 16.7 million residents consequently score 156.37 points for the West in 2000 CE. The smallest score I considered worth recording, 0.01 points, required just over 1,000 people, which means that—unlike the energy capture scores—organization scores *do* fall to zero, becoming too small to measure before 4000 BCE in the East and 7500 BCE in the West.

The main challenges for calculating organization this way are empirical. For early settlements we have to rely on archaeology and ethnographic/historical analogies. Estimates depend heavily on measurements of settlement area and extrapolation from documented densities. Fletcher (1995) shows how much densities vary, although they do seem to follow general rules. In some cases, such as classical Greece (Hansen 2006), estimates are probably quite reliable; in others, like 3rd-2nd millennium BCE Mesopotamia, they may be less so (Postgate 1994b). On the whole, well-documented premodern cities rarely have densities over

200/ha, and numbers closer to 100/ha are more common. Occasionally, premodern towns might go as high as 500/ha, but such densities are exceptional and need very clear evidence. Very small villages and select areas within 20th-21st century CE supercities, however, sometimes have densities well over 500/ha.

Beginning in ancient times, we get some contemporary literary observations on city size, but these are often unreliable, since the inhabitants of ancient cities often did not themselves know how many people lived around them. This means that archaeology and analogy remain very important until the modern era—although since there are no contemporary cities quite like premodern urban giants such as Rome and Chang'an, analogies are more problematic for much of the last 3,000 years than for prehistory. In more recent times data on food imports sometimes survive, which give another way to control population size; and in the most modern periods we can draw on fairly accurate government statistics.

Several writers have offered overviews of urban history with precise figures. Tertius Chandler's *Four Thousand Years of Urban Growth* (1987) is the most widely cited reference work, although he provides few sources, and some of the estimates seem erratic. His figures for medieval Islamic cities are particularly high, and, like many historians, he greatly exaggerates the size of ancient Greek cities, suggesting for example (1987: 461) that Athens had 155,000 residents in 430 BCE, rather than the 30,000-40,000 that probably lived there (Morris 2006: 42-43). His estimates for medieval and early modern China, however, avoid the inflated numbers that historians often propose.[1] Paul Bairoch's *Cities and Economic Development* (1988) is also valuable, but less systematic. George Modelski's website "Cities of the Ancient World" (https://faculty.washington.edu/modelski/WCITI2.html) only covers Southwest Asia and Egypt in the period down to 1200 BCE. The Wikipedia entry "Historical Urban Community Sizes" (http://en.wikipedia.org/wiki/Historical_urban_community_sizes) depends largely on data gathered from Chandler, Modelski, and Bairoch.

While there would be some advantages to taking a single source like Chandler and then relying on it consistently, the drawbacks seem to outweigh them. The main advantage of relying on a single source is normally that it makes errors more consistent and hence easier to compensate for; however, in this case the errors seem to be rather randomly distributed. I decided instead to rely on what seemed to be the best experts

[1] Chandler's estimates for 2000 BCE-1988 CE are also on line at http://web.archive.org/web/20080211233018/http://www.etext.org/Politics/World.Systems/datasets/citypop/civilizations/citypops_2000BC-1988AD.

for each time and place, cross-checking their scores to reduce idiosyncrasies. I summarize these results for Western and Eastern cities, in each case providing my sources, any particular problems involved in the estimate, and, if the estimate is my own, my reasons for choosing that figure, collecting my estimates for the West in Table 6 and for the East in Table 7. Among archaeologists working on periods before 3000 BCE in the West and before 2000 BCE and among historians working on the 2nd millennium CE it is conventional to offer estimates for city sizes, even if they vary widely, but unfortunately historians and archaeologists working on periods between 3000/2000 BCE and 1000 CE are much more hesitant to hazard concrete estimates.

[9.2] *Estimates of Western city sizes*

Table 6 Western maximum settlement sizes, 8000 BCE-2000 CE

8000 BCE: Mureybet, perhaps 500
7000 BCE: Beidha, Basta, Çatalhöyük, 1,000; 0.01 points
6000 BCE: Çatalhöyük, 3,000; 0.03 points
5000 BCE: Tell Brak, 4,000; 0.04 points
4000 BCE: Uruk, Tell Brak, 5,000; 0.05 points
3500 BCE: Uruk, Susa, Tell Brak, 8,000; 0.09 points
3000 BCE: Uruk, 45,000; 0.42 points
2500 BCE: Uruk, 50,000; 0.47 points
2250 BCE: Akkad, Memphis, 35,000; 0.33 points
2000 BCE: Memphis, Ur, 60,000; 0.56 points
1750 BCE: Babylon, 65,000; 0.61 points
1500 BCE: Uruk, Thebes, 75,000; 0.7 points
1400 BCE: Thebes, 80,000; 0.75 points
1300 BCE: Thebes, 80,000; 0.75 points
1200 BCE: Babylon, Thebes, 80,000; 0.75 points
1100 BCE: Memphis, Thebes, Tanis, 50,000; 0.47 points
1000 BCE: Thebes, 50,000; 0.47 points
900 BCE: Thebes, 50,000; 0.47 points
800 BCE: Nimrud/Kalhu, 75,000; 0.7 points
700 BCE: Nineveh, 100,000; 0.94 points
600 BCE: Babylon, 125,000; 1.17 points
500 BCE: Babylon, 150,000; 1.4 points
400 BCE: Babylon, 150,000; 1.4 points
300 BCE: Babylon, Alexandria, 150,000; 1.4 points
200 BCE: Alexandria, 300,000; 2.81 points
100 BCE: Alexandria, perhaps Rome, 400,000; 3.75 points
1 BCE/CE: Rome, 1,000,000; 9.36 points

100 CE: Rome, 1,000,000; 9.36 points
200 CE: Rome, 1,000,000; 9.36 points
300 CE: Rome, 800,000; 7.49 points
400 CE: Rome, 800,000; 7.49 points
500 CE: Constantinople, 450,000; 4.23 points
600 CE: Constantinople, 150,000; 1.41 points
700 CE: Constantinople, 125,000; 1.17 points
800 CE: Baghdad, 175,000; 1.64 points
900 CE: Cordoba, 175,000; 1.64 points
1000 CE: Cordoba, 200,000; 1.87 points
1100 CE: Constantinople, 250,000; 2.34 points
1200 CE: Baghdad, Cairo, Constantinople, 250,000; 2.34 points
1300 CE: Cairo, 400,000; 3.75 points
1400 CE: Cairo, 125,000; 1.17 points
1500 CE: Cairo, 400,000; 3.75 points
1600 CE: Constantinople, 400,000; 3.75 points
1700 CE: London and Constantinople, 600,000; 5.62 points
1800 CE: London, 900,000; 8.43 points
1900 CE: London, 6,600,000; 61.8 points
2000 CE: New York, 16,700,000; 156.37 points

For each date (every century back to 1400 BCE; every 250 years, 1500-2500 BCE; every 500 years, 2500-4000 BCE; every thousand years before 5000 BCE [Morris 2010: 158]) I provide first my identification of the largest city and estimate for its population, then my main source and the number of points the city scores on the social development index, then brief comments on conflicting estimates and the nature of the evidence.

2000 CE: New York, 16,700,000 (*Economist* 2004: 20); 156.37 points. *The Economist Pocket World in Figures* estimated the population of Mexico City in 2000 CE at 18,100,000 and that of São Paolo at 18,000,000, but New York remains the largest city in the Western core (i.e., the USA, the borderlands of Canada, and northwest and central Europe).

1900 CE: London, 6,600,000 (Bayly 2004: 189, and many other sources); 61.8 points. Chandler (1987: 492) estimates London at 6,480,000, and there seems to be general agreement among urban historians on a figure around 6.5 million, based on multiple kinds of official statistics.

1800 CE: London, 900,000 (Braudel 1981: 528); 8.43 points. There is a little more debate about populations in 1800 CE than those for 1900, and some sources put London a little lower (e.g., Chandler 1987: 485 says 681,000).

The evidence consists of a combination of government statistics and eyewitness comments. The next-largest Western city was probably Constantinople, which Chandler puts at 570,000.

1700 CE: London and Constantinople, 600,000 (Cipolla 1993: 304; Braudel 1981: 548); 5.62 points. Chandler (1987: 483) estimates Constantinople at 700,000 and London at 550,000; Bairoch (1988: 378) suggests that Constantinople was the biggest city in the world, with 650,000–1,000,000 people. John Haldon, co-director of the International Medieval Logistics Project (http://www.medievallogistics.bham.ac.uk/), suggests (personal communication, October 2005) that Constantinople may have been closer to 700,000 people. The arguments combine tax registers, records of food imports, records of births and deaths, and the area covered by the cities.

1600 CE: Constantinople, 400,000 (John Haldon, personal communication, October 2005); 3.75 points. Eric Jones (2003: 178) suggests that Constantinople was 600,000; Chandler (1987: 481) says 700,000; and Bairoch (1988: 378) says 650,000–1,000,000. The evidence still consists mostly of tax registers, records of food imports, records of births and deaths, and the area covered by the cities, but its quality declines sharply by 1600 CE.

1500 CE: Cairo, 400,000 (Chandler 1987: 478); 3.75 points. Frank (1998: 12 says that Bairoch estimated Cairo at 450,000. Bairoch (1988: 378) also suggests that Constantinople had 300,000–500,000 residents, but John Haldon (pers. comm., October 2005) thinks that so soon after the 1453 sack its population was just 100,000. The evidence is still of the same types as for 1600 and 1700, but between roughly 500 and 1500 CE there is much more debate on how to interpret it. Historians of Europe and those of the Middle East also sometimes use very different methods, often leading to unrealistically high estimates for Islamic cities, implying densities of 500-1,000/ha. Historians of Muslim cities also tend to be more cautious than European historians in hazarding estimates. Cairo seems to be particularly problematic. The evidence consists mostly of military registers, contemporary impressions, and the areas covered by the cities, but there are many challenges involved in interpreting it (Abu-Lughod 1971).

1400 CE: Cairo, 125,000; 1.17 points. This is my own estimate, based on comparison with the extremely high mortality rates in European cities during the Black Death (see especially Benedictow 2004). Chandler (1987:

476) suggested Cairo still had 360,000 residents in 1400, but that would imply that the population had fallen just 20% from its pre-plague peak of 450,000, which seems inconsistent with the accounts in Abu-Lughod 1971 and Dols 1974. For the evidence, see under 1500 CE.

1300 CE: Cairo, 400,000 (based on Brett 2005: 4, suggesting that Cairo's population peaked at 450,000 on the eve of the Black Death in the 1340s); 3.75 points. On the sources and difficulties, see under 1500 CE.

1200 CE: Baghdad, Cairo, Constantinople, 250,000 (Hourani 1991: 112; Chandler 1987: 473; Bairoch 1988: 378; Haldon, pers. comm., October 2005); 2.34 points. There is some disagreement over the populations of these cities, but general consensus that all had populations between 200,000 and 300,000. Some estimates, however (particularly for Baghdad), go much higher (see under 1000 CE below).

1100 CE: Constantinople, 250,000 (Haldon, pers. comm., October 2005); 2.34 points. Wickham (2005: 612) also suggests that Cairo also reached 250,000 in the 11th century.

1000 CE: Cordoba, 200,000; 1.87 points. This is my own estimate. Several estimates put Cordoba at 400,000-500,000 (e.g., Bairoch 1988: 118; De Long and Shleifer 1993: 678; Chandler 1987: 467). Chandler also thinks that Constantinople's population was 300,000 and Baghdad's 125,000. These estimates, however, all seem very high. Haldon (pers. comm., October 2005) puts Constantinople at 150,000, and the settled area of Baghdad (550-860 ha; Hodges and Whitehouse 1983: 128) seems too small for a population above 100,000. Cordoba covered roughly twice as large an area, and I therefore suggest that its population peaked around 200,000 in the 11th century.

900 CE: Cordoba, 175,000; 1.64 points. This is my own estimate. Chandler (1987: 468) estimates Baghdad at 900,000, Constantinople at 300,000, and Cordoba at 200,000. Several other scholars also put the population of Baghdad quite high (e.g., Lapidus 2002: 56, at 300,000-500,000), though nowhere near as high as Chandler. Lapidus' estimate would require a density of 350-900/ha, and Chandler's 1,050-1,600. These seem extraordinarily high; other large preindustrial cities rarely managed 200/ha (Fletcher 1995).

800 CE: Baghdad, 175,000; 1.64 points. Again this is my own estimate. Baghdad clearly grew very quickly after its foundation in 762, and its population may have peaked before the sieges of 812-813 and 865. Chandler (1987: 468) estimates 700,000 for Baghdad, 250,000 for Constantinople, and 160,000 for Cordoba. Again, these numbers seem very high given the physical size of the cities and the generally small populations in the Western core at this point, after centuries of plagues. Haldon (pers. comm., October 2005) sets the population of Constantinople in 750 CE at just 40,000-50,000.

700 CE: Constantinople, 125,000; 1.17 points. My estimate, extrapolated from Haldon's figures for 500 and 750 CE. Constantinople's population clearly fell very steeply between 550 and 750 CE, beginning with the Justinianic plague and accelerating after the Persian Wars in the 610s and the breakdown of the Constantinople-Egypt grain trade in the 640s. Haldon (pers. comm., October 2005) estimates Constantinople's population at 40,000-50,000 in 750 CE, but the evidence does not allow us to be sure how much of the fall came before 700 and how much after. I assume that the most severe period of decline came after 700 (cf. Haldon 1990: 114-17), with the population falling just 15-20% in the 7th century then a further 65% in the 8th century.

600 CE: Constantinople, 150,000; 1.41 points. See discussion under 700 CE.

500 CE: Constantinople, 450,000 (Haldon, pers. comm., October 2005); 4.23 points. Cameron (1993: 13) and Wickham (2005: 29) suggest 500,000, and Chandler (1987: 465) says 400,000. The arguments depend heavily on our sources for the grain supply (Mango 1985; Sirks 1991). Rome's population fell very quickly after the loss of North Africa in 439, probably shrinking to just 20,000-40,000 by about 600 CE (Wickham 2005: 33). Wickham (2005: 653) calls 7th-century Rome an "urban village."

400 CE: Rome, 800,000 (Hodges and Whitehouse 1983: 48-52; Krautheimer 1983: 109, though cf. 154 n. 12); 7.49 points. The population of Rome probably fell during the 3rd century CE, but it is hard to say just how much. It was clearly by far the biggest city in the Mediterranean in the 4th century, though, and may have still had three quarters of a million residents as late as the Vandal conquest of North Africa in 439. After that, the population fell very sharply. Wickham (2005: 33) suggests a lower figure, of 500,000 in the early 5th century.

300 CE: Rome, 800,000; 7.49 points. See under 400 CE. The number of urban districts was lower in 300 CE than in 400, which may mean that population fell more sharply in the 3rd century than I have allowed for and then grew again during the 4th century, but there is no way to be sure.

200 CE: Rome, 1,000,000; 9.36 points. Most scholars think that Rome had a million residents by the late 1st century BCE (e.g., Hopkins 1978: 96-98; Morley 1996: 33-54), and that the population stayed somewhere around that level till at least 200 CE, then declined significantly in the 3rd century and dramatically in the 5th. We probably cannot be more precise than that, though. Some scholars (e.g., Storey 1997) suggest that Rome was much smaller, perhaps never exceeding 500,000. That is very much a minority view, however, and 500,000 is probably the minimum possible number (Salmon 1974: 11-22). The arguments depend partly on a separate set of heated debates over the population of Italy as a whole (either 4-5 million or 12+ million; see Scheidel 2001: 52-57, Lo Cascio 1997) and partly on the density of population within the city itself.

100 CE: Rome, 1,000,000; 9.36 points. This is the generally accepted figure for the first two centuries CE (see above under 200 CE). It is perfectly possible that the population kept growing until about 200 CE, but it probably never greatly exceeded a million (see discussion in Morley 1996: 39).

1 BCE/CE. Rome, 1,000,000; 9.36 points. See under 200 CE.

100 BCE: Alexandria, perhaps Rome, 400,000 (Scheidel 2004; Morley 1996: 39); 3.75 points. The grain trade statistics (Delia 1989) are again important.

200 BCE: Alexandria, 300,000 (Scheidel 2004); 2.81 points.

300 BCE: Babylon, Alexandria, 150,000 (Boiy 2004; Scheidel 2004); 1.4 points. Scheidel suggests that Alexandria grew very rapidly after its foundation in 331 BCE, and then slowed down in the 3rd and 2nd centuries BCE.

400 BCE: Babylon, 150,000 (my estimate, calculated from Wiseman 1985, George 1993, Boiy 2004); 1.4 points. Estimates depend on city-size, densities, and interpretation of contemporary comments by Herodotus (1.178, 191) and Aristotle (*Politics* 1276a30). Some estimates for Babylon are

lower; Gates (2003: 181) suggests 80,000, which seems reasonable to me for 2nd-millennium BCE Babylon, but may be too low for the mid-1st millennium BCE.

500 BCE: Babylon, 150,000; 1.4 points. See under 400 BCE.

600 BCE: Babylon, 125,000; 1.17 points. My estimate, extrapolated from estimates for 400 BCE and 500 BCE.

700 BCE: Nineveh, 100,000 (my estimate, derived from sources in van de Mieroop 1997: 97); 0.94 points. Estimates once again depend largely on guesses at densities and interpretation of contemporary comments such as Jonah (3.3, 4.11). Consequently, they vary wildly; Åkerman (2001), for instance, suggests 300,000 at Nineveh, which would mean a density of 630/ha.

800 BCE: Nimrud (also known as Kalhu), 75,000; 0.7 points. See under 700 BCE.

900 BCE: Thebes, 50,000 (extrapolated from Chandler 1987: 460); 0.47 points. Egyptian written sources during the Third Intermediate Period (c. 1100-650 BCE) are particularly poor (Kitchen 1986), and archaeologists have rarely made settlement excavations of sites of this period a priority, so our estimates are particularly speculative.

1000 BCE: Thebes, 50,000 (Chandler 1987: 460); 0.47 points.

1100 BCE: Memphis, Thebes, Tanis, 50,000 (Chandler 1987: 460; for Tanis, calculations from plans in Yoyotte 1987); 0.47 points.

1200 BCE: Babylon, Thebes, 80,000 (Chandler 1987: 460); 0.75 points. On Babylon generally, see Oates 1979, Finkel and Seymour 2009, and a convenient on-line summary from the *International Standard Bible Encyclopedia* (http://bibleencyclopedia.com/babylon.htm); on New Kingdom Thebes, Nims 1965, Kemp 1989: 201-202. The residential areas of the New Kingdom city at Thebes and Bronze Age Babylon lie largely beneath the water table, which makes serious study difficult. However, Thebes was clearly much larger than the Middle Kingdom city, which covered only about 50 ha, and was probably the world's largest city between 1500 and

1200 BCE. Most of what little is known about Babylon, from early German excavations in the Merkes neighborhood, can be found in Reuther 1926.

1300 BCE: Thebes, 80,000 (Chandler 1897: 460); 0.75 points.

1400 BCE: Thebes, 80,000 (Chandler 1987: 460); 0.75 points.

1500 BCE: Uruk, Thebes, 75,000 (Chandler 1987: 460; van de Mieroop 1997: 95); 0.7 points. Some estimates are much higher; Christian (2004: 295), for instance, suggests that Babylon reached 200,000 people.

1750 BCE: Babylon, 65,000; 0.61 points. My estimate. We remain ignorant about the size and density of population in Hammurabi's Babylon (reigned 1792-1750 BCE on the "long chronology"), which not only lies under the water table but is also buried under 1st-millennium BCE Babylon. It was probably the biggest city in the world, commanding an extensive empire (van de Mieroop 2004), and the remains of other 18th-century BCE Babylonian cities suggest quite high densities (Oates 1979: 76-82), which suggest that a guess of around 65,000 will be in the right range; but we lack information for a proper estimate (van de Mieroop 2004: 93).

2000 BCE: Memphis, Ur, 60,000 (Chandler 1987: 460); 0.56 points. There is so much disagreement over population densities in 3rd-millennium BCE cities (particularly in Mesopotamia; see Postgate 1994b) that most archaeologists avoid offering numbers, and Chandler's estimates have largely stood unchallenged. That said, we can be fairly confident that no city had 100,000 people in the 3rd or even the 2nd millennium BCE, and that the biggest cities were in the 50,000 ± 15,000 range (i.e., 0.33-0.61 points). The figures for Uruk, based on Adams' survey (1981), are probably more reliable than those for Memphis and Ur, and particularly than the guess for Akkad, which has not even been located.

2250 BCE: Akkad, Memphis, 35,000 (Chandler 1987: 460); 0.33 points. See under 2000 BCE.

2500 BCE: Uruk, 50,000 (Modelski Table 2; Adams 1981: 85); 0.47 points. See under 2000 BCE.

3000 BCE: Uruk, 45,000 (Adams 1981: 85; Nissen 1993; Maisels 1990: 141); 0.42 points. See under 2000 BCE.

3500 BCE: Uruk, Susa, Tell Brak, 8,000; 0.09 points. The numbers for Uruk and Susa are pure guesses, rather than proper estimates. Uruk seems to have grown very rapidly between 3500 and 3000 BCE. It was clearly the largest settlement in Sumer in 3500 (Adams 1981), but with the evidence currently available we be very precise about its population. The remains at Susa also show that it was a substantial town, but given the poor quality of the 19th-century excavations we are unable to put a precise population figure on it. The recent excavations at Tell Brak (Oates et al., forthcoming; http://www.mcdonald.cam.ac.uk/projects/brak/index.htm) suggest that it reached 10,000 people by 3000 BCE, and had been very big—perhaps even the largest settlement in the world—across much of the previous 2,000 years. However, no good estimates yet exist.

4000 BCE: Uruk, Tell Brak, 5,000; 0.05 points. See under 3500 BCE.

5000 BCE: Tell Brak, 4,000; 0.04 points. See under 3500 BCE.

6000 BCE: Çatalhöyük, 3,000 (Hodder 2006); 0.03 points

7000 BCE: Beidha, Basta, Çatalhöyük (Mithen 2003: Hodder 2006), 1,000; 0.01 points. Jericho may have been roughly the same size, and there may also have been some earlier settlements of roughly this scale; Maisels (1990: 93-94) suggests that Mureybet had 500-1,000 residents around 8000 BCE.

8000 BCE: Probably no site in the Western core had as many as 500 people before 7500 BCE at the earliest, which means that none reaches 0.01 points on the index, the smallest score I record.

[9.3] *Estimates of Eastern city sizes*

Table 7 Eastern maximum settlement sizes, 4000 BCE-2000 CE

4000 BCE: Jiangzhai, Jiahu, 300
3500 BCE: Xipo, 2,000; 0.02 points
3000 BCE: Dadiwan, 5,000; 0.05 points
2500 BCE: Taosi, Liangchengzhen, Yaowangcheng, 10,000; 0.09 points
2250 BCE: Taosi, Liangchengzhen, Yaowangcheng, 14,000; 0.13 points
2000 BCE: Fengcheng-Nanshui, 11,000; 0.1 points
1750 BCE: Erlitou, 24,000; 0.22 points
1500 BCE: Zhengzhou, 35,000; 0.33 points
1400 BCE: Zhengzhou, 35,000; 0.33 points

1300 BCE: Zhengzhou, 35,000; 0.33 points
1200 BCE: Anyang, 50,000; 0.47 points
1100 BCE: Anyang, 50,000; 0.47 points
1000 BCE: Luoyi, Feng, 35,000; 0.33 points
900 BCE: Luoyi, Feng, 40,000; 0.37 points
800 BCE: Luoyi, Feng, 45,000; 0.42 points
700 BCE: Linzi, Luoyi, 55,000; 0.51 points
600 BCE: Linzi, Luoyi, 65,000; 0.61 points
500 BCE: Linzi, 80,000; 0.75 points
400 BCE: Linzi, Qufu, Luoyi, Xinzheng, Wuyang, 100,000; 0.94 points
300 BCE: Linzi, Qufu, Luoyi, Xinzheng, Wuyang, 125,000; 1.17 points
200 BCE: Chang'an, 250,000; 2.81 points
100 BCE: Chang'an, 375,000; 3.75 points
1 BCE/CE: Chang'an, 500,000; 4.68 points
100 CE: Luoyang, 420,000; 3.93 points
200 CE: Chang'an, 120,000; 1.12 points
300 CE: Pingyang, Chang'an, Luoyang, Xuchang, Ye, 140,000; 1.31 points
400 CE: Pingcheng, 200,000; 1.87 points
500 CE: Luoyang, 200,000; 1.87 points
600 CE: Daxingcheng/Chang'an, 600,000; 5.63 points
700 CE: Chang'an, 1,000,000; 9.36 points
800 CE: Chang'an, 1,000,000; 9.36 points
900 CE: Chang'an, 750,000; 7 points
1000 CE: Kaifeng, 1,000,000; 9.36 points
1100 CE: Kaifeng, 1,000,000; 9.36 points
1200 CE: Hangzhou, 1,000,000; 9.36 points
1300 CE: Hangzhou, 800,000; 7.5 points
1400 CE: Nanjing, 500,000; 4.68 points
1500 CE: Beijing, 678,000; 6.35 points
1600 CE: Beijing, 700,000; 6.55 points
1700 CE: Beijing, 650,000; 6.09 points
1800 CE: Beijing, 1,100,000; 10.3 points
1900 CE: Tokyo, 1,750,000; 16.39 points
2000 CE: Tokyo, 26,400,000; 250 points

For each date (every century back to 1400 BCE; every 250 years, 1500-2500 BCE; every 500 years, 2500-4000 BCE; every thousand years before 5000 BCE [Morris 2010: 158]) I provide first my identification of the largest city and estimate for its population, then my main source and the number of points the city scores on the social development index, then brief comments on conflicting estimates and the nature of the evidence.

2000 CE: Tokyo, 26,400,000 (*Economist* 2004: 20); 250 points. The largest city in China was Shanghai (12,900,000; 120.79 points).

1900 CE: Tokyo, 1,750,000 (Bayly 2004: 189, and many other sources); 16.39 points. Some urban historians make slightly lower estimates (e.g., Chandler 1987: 492 suggests 1.5 million), but there seems to be general agreement on a figure in this area, based on multiple kinds of official statistics from censuses, tax returns, food supply, and military personnel. In China, the largest city was Beijing, with around 1,100,000 residents (10.3 points).

1800 CE: Beijing, 1,100,000 (Chandler 1987: 485); 10.3 points. Estimates for Qing-era Beijing are based heavily on statistics for food imports, and vary wildly. At different points, Braudel suggested 3 million (1981: 526) or 2-3 million (1981: 540). Chandler's estimate seems more in line with social historians' accounts of Qing Beijing (e.g., Rowe 2009: 90-148).

1700 CE: Beijing, 650,000 (Chandler 1987: 483); 6.09 points. Beijing's population fell sharply after the terrible sack of 1644, and in 1700 had probably not yet returned to its 1600 level. Some historians, however, suggest much higher figures (e.g., Mote 1999: 763, proposing 1.3 million).

1600 CE: Beijing, 700,000 (Chandler 1987: 481, suggesting the very precise number of 706,000); 6.55 points. Some historians suggest higher figures (e.g., Frank 1998: 109 proposes about 1 million for Nanjing), but rarely provide evidence to support them.

1500 CE: Beijing, 678,000 (Chandler 1987: 478); 6.35 points. Mote (1999: 763) estimated the population of Nanjing and Beijing at about 1 million each through the 16th and 17th centuries, but this seems unlikely, both because it is very high (Beijing probably did not reach 1 million till late in the 18th century) and because Nanjing is generally believed to have seen a roughly 50% population decline Beijing replaced it as the capital in 1421, as Mote himself recognizes elsewhere (1977: 150). Bairoch (1988: 356) agreed with a lower estimate, thinking that Beijing had at least 600,000 people in 1600.

1400 CE: Nanjing, 500,000 (Chandler 1987: 476 says 487,000); 4.68 points. Mote (1977: 132, 138) says that he thinks Nanjing's population was about 1 million, but his own rough calculation (1977: 145) actually comes to 400,000-500,000.

1300 CE: Hangzhou, 800,000 (Bairoch 1988: 355); 7.5 points. Bairoch suggests that four other Chinese cities around 1300 had populations in the 200,000-500,000 range while Hangzhou was "perhaps considerably larger." His calculations from the figures for rice consumption, however, point more precisely to 800,000, while Elvin (1973: 177) calculates 600,000-700,000 from the rice figures. Rozman (1973: 35) also thought 12th-13th century Hangzhou's population was over 500,000, and could have been as high as 1 million. Kuhn (2009: 205) and Christian (2004: 368) also lean toward 1 million, and Skinner (1977: 30), 1.2 million. I take the higher figure of roughly 1 million for 1200 CE, and the lower figure of 800,000 for 1300 CE, by which time population was falling across China as a whole. The city was certainly the biggest in the world when Marco Polo visited in the late 13 century (Kuhn 2009: 205-209), but the figure implied by Marco's comments—5-7 million—must be far too high. There was probably no way Marco could have known Hangzhou's population, beyond the simple fact that it was enormous compared to European or Muslim cities of his day.

1200 CE: Hangzhou, 1,000,000; 9.36 points. See under 1300 CE.

1100 CE: Kaifeng, 1,000,000 (Mote 1999: 164-65; Skinner 1977a: 30; Kuhn 2009: 195); 9.36 points. Chandler (1987: 467) and Bairoch (1988: 352) think Kaifeng was smaller (suggesting 400,000 and 400,000-450,000, respectively), but this seems at odds with the descriptions of Kaifeng (Kuhn 2009: 191-205; de Pee 2010). Much of the uncertainty seems to revolve around the question of which wards to count as "urban." The New City was built in 955 with a 27 km fortification wall (extended by 3.3 km in 962), adding 75 new wards to the Old City's 46, but well before 1000 CE the population was spilling out beyond the walls. By 1021 fourteen large new extramural wards had been recognized. Official statistics say that 890,000 people lived in Kaifeng prefecture around 980 CE, increasing to 1.3 million in 1103, with some parts of the city achieving densities of 500/ha (Kuhn 2009: 195). If we count only the people within the fortification walls, Chandler's and Bairoch's estimates are probably reasonable; if we count the whole population, Mote's, Skinner's, and Kuhn's preference for the official figures seems sensible. I lean toward the latter, but given the ambiguities in the data I simply make an approximate estimate of 1 million people. According to the official figures, Hangzhou probably also had 800,000 to 1 million residents by 1100 (Kuhn 2009: 205).

1000 CE: Kaifeng, 1,000,000; 9.36 points. See under 1100 CE.

900 CE: Chang'an, 750,000; 7 points. My estimate. Chinese historians rarely express opinions on Chang'an's population around 900 CE. The bandit Huang Chao sacked the city repeatedly in the late 870s, burning it to the ground completely in 880 and 883 and, not surprisingly, causing its population to go into sharp decline (Somers 1979). Prior to the late 870s Chang'an was certainly the world's biggest city. Benn (2002: 46) suggests that its population reached 2 million (see also Wright 1978: 201), and Kuhn (2009: 191) suggests "more than one million people," but it is hard to see how even after the construction of the Grand Canal enough grain could have been shipped to Chang'an to feed a population of the size proposed by Benn. Skinner's suggestion (1977a: 30) that Chang'an probably had around a million residents in middle Tang times seems more plausible, and I use that number for 800 and 700 CE. The city walls, enclosing just over 30 square miles, could certainly have contained a million people, but Benn's 2 million would call for improbably high densities. It is much less clear, though, how sudden the collapse in population was from the 870s onward. Primary sources say that the city was completely ruined when Emperor Xizong returned there in 885 (Lewis 2009b: 72), but that is clearly an overstatement, because the dynasty remained there for another 20 years, until the warlord Zhu Wen ordered all the remaining buildings pulled down in 904. I have assumed that Chang'an remained a major population center until that point. If that is wrong, however, the East's organization/city size score in 900 CE must still have been high, since Luoyang probably had 500,000-750,000 residents at that time. Wu Zetian is supposed to have transferred 100,000 families to Luoyang when she made it her home in the late 7th century, and Benn (2002: 46) put the population as high as 1 million. Rozman (1973), however, suggested 500,000 for Luoyang.

800 CE: Chang'an, 1,000,000 (Skinner 1977a: 30; Kuhn 2009: 191); 9.36 points. See under 900 CE.

700 CE: Chang'an, 1,000,000 (Skinner 1977a: 30; Kuhn 2009: 191); 9.36 points. See under 900 CE.

600 CE: Daxingcheng (renamed Chang'an by the Tang dynasty in the 7th century), 600,000; 5.63 points. My estimate. The Sui dynasty built Daxingcheng as their new capital with a walled area of more than 30 square miles to accommodate the population of about 1 million that it would have in the 7th century (by which time the Tang dynasty had renamed it

Chang'an). When the emperor took up official residence in 583, though, the city was still a construction site, with many wards unoccupied. The population must already have been very large in 600 CE, since many tens of thousands of laborers would have been needed for the project, plus families, not to mention plenty of officials and workers (plus families), and thousands of monks and nuns at more than 100 temples and monasteries (Wright 1978: 84-90). Further, when the Sui overwhelmed southern China's Chen dynasty in 589, enormous numbers of people from the south were deported to Daxingcheng (Lewis 2009a: 252).

500 CE: Luoyang, 200,000 (Chandler 1987: 465); 1.87 points. Emperor Xiaowen of Northern Wei relocated his capital from Pingcheng to Luoyang in 493, and according to the texts moved 150,000 warriors there by 495, granting them farmlands around Luoyang. The city grew much more during the 6th century, perhaps reaching 600,000 people (Graff 2002: 98), like Daxingcheng.

400 CE: Pingcheng, 200,000 (my estimate); 1.87 points. There were several large cities in northern China around 400 CE, but Pingcheng (renamed Datong in 1048) was probably the biggest. The texts say that in 398 CE, 100,000 Xianbei were forcibly relocated to Pingcheng, and in 399, another 100,000 peasants from Henan and 2,000 wealthy ethnic Chinese families were taken there too. With the partial exception of Ye, the archaeological evidence for cities in the period 200-400 CE is particularly poor (Dien 2007: 19-32).

300 CE: Pingyang, Chang'an, Luoyang, Xuchang, Ye, 140,000 (my estimate); 1.31 points. In the 4th-5th centuries CE it could be difficult to define what exactly counted as a city; Graff (2002: 35-51) characterizes North Chinese cities as being like giant encampments, with the major wars of the period being basically slave raids in which warlords rounded up tens of thousands of families and concentrated them in and around their own fortress to work the abundantly available land. Pingyang, Chang'an, Luoyang, Xuchang, and Ye all became large cities in the years around 300 CE, probably somewhat bigger than the largest cities had been around 200 CE and somewhat smaller than the largest cities would be in 400 CE.

200 CE: Chang'an, 120,000 (my estimate); 1.12 points. In 190 the warlord Dong Zhuo pillaged and destroyed Luoyang, moving its population to Chang'an, and in 196 Cao Cao relocated the imperial court to Chang'an

(only for the court to move back to Luoyang as soon as Cao Cao died). These cities were clearly much smaller than Luoyang had been in 100 CE, let alone Chang'an in 1 CE.

100 CE: Luoyang, 420,000 (Chandler 1987: 463); 3.93 points. Archaeologists and historians have described the layout of the major Han cities in some detail (e.g., Bielenstein 1976; Lewis 2006, 2007: 75-101; X. Li 1985; Steinhardt 1990; 46-53; Wang 1982; Wu 1999: 653-65), but rarely offer population estimates. The accounts of the excavated areas and surviving city plans make it clear that Chang'an and Luoyang (capitals for most of the periods 206 BCE-32 CE and 32-220 CE, respectively) had populations running into several hundred thousands. The literary sources say that the Qin First Emperor forcibly resettled 120,000 families in his capital of Xianyang in the 220s BCE and moved more people there to tend his tomb site in the 210s (Lewis 2007: 89). These figures may well be exaggerated, but Xianyang probably did have 200,000+ residents at the time of his death on 210 BCE, and the Han dynasty's new capital at Chang'an was at least as large. By the 1st century BCE Chang'an's two main markets covered 50 and 25 ha, which similarly suggest a very large population. The city covered an enormous area of 44.5 km^2, but the density of occupation within the excavated areas combined with Chang'an's notorious food supply difficulties suggests that it was never as populous as contemporary Rome. I estimate that it probably peaked toward the end of the Western Han dynasty (i.e., c. 1 BCE/CE) around 500,000 people, though the margin of error in this guess could easily be 20 percent.

Estimates are complicated by the fact that the city also had satellite cities around it, particularly those that grew up around the imperial tombs, scattered for 30 km along the Zheng Guo canal and 20 km along the Ba and Chan Rivers. If we combine Chang'an itself with these satellites, their total population may have surpassed Rome, but since they appear to have been independent cities in every way, I have not done that. There is also some evidence that Chang'an's growth slowed after 100 BCE, and that there was little new state construction after Emperor Wudi's death in 87 BCE.

Luoyang was smaller than Chang'an, but was apparently more densely populated. I therefore make a slightly lower estimate for Luoyang at its peak, of 420,000 people in 100 CE. Again, a margin of error of ± 20 percent seems plausible.

1 BCE/CE: Chang'an, 500,000 (my estimate); 4.68 points. See under 100 CE.

100 BCE: Chang'an, 375,000 (my estimate); 3.75 points. See under 100 CE.

200 BCE: Chang'an, 250,000 (my estimate); 2.81 points. See under 100 CE.

300 BCE: Linzi, Qufu, Luoyi, Xinzheng, Wuyang, 125,000 (my estimate); 1.17 points. The cities of the Spring-and-Autumn and Warring States periods remain poorly known archaeologically, but it seems clear that they increased steadily in size across the second half of the 1st millennium BCE (Wu 1999: 653-65). The walls of the largest cities (Wuyang [state of Yan], 27 km; Xinzheng [Zheng/Hann], 16 km; Linzi [Qi], 15 km; Qufu [Lu], 14 km; Luoyi, later renamed Luoyang [Zhou], 12 km) typically encompassed areas of 9-15 km^2, suggesting populations in the 100,000-200,000 range. However, some of the cities clearly had large ceremonial and industrial areas, and (at least at first) large areas were probably incorporated within the walls in anticipation of future growth. The estimates that follow are my own. The errors involved are probably larger than for Han cities, and may run as high as ± 50 percent.

The ancient literary sources are not very helpful; the *Shi ji* (69 p. 2257 = Nienhauser 1994: 106) says that Linzi in Qi had 70,000 households and boasted 210,000 adult males. The city was so crowded, Sima Qian commented, that "when [people] shake off sweat, it feels like rain." His numbers imply a total population of perhaps 350,000-750,000, which would make Linzi much bigger than contemporary Babylon. This seems impossibly high, though, given the physical size of the city; it would also mean that the populations of the largest Chinese cities in fact did not grow between about 500 and 1 BCE, even though the evidence suggests unequivocally that they at least doubled and probably quadrupled in size across this period.

Bairoch (1988: 44) suggested that four to six cities had populations over 100,000 during the Warring States period (480-221 BCE), which is broadly in line with the estimates I make here.

400 BCE: Linzi, Qufu, Luoyi, Xinzheng, Wuyang, 100,000 (my estimate); 0.94 points. See under 300 BCE.

500 BCE: Linzi, 80,000 (my estimate); 0.75 points. See under 300 BCE.

600 BCE: Linzi, Luoyi, 65,000 (my estimate); 0.61 points. The evidence is even poorer for the first half of the 1st millennium BCE than it is for the second half (or, for that matter, for the later 2nd millennium BCE). We can

be certain that the biggest cities around 1000 BCE were smaller than those of those around 500 BCE, but we cannot be sure how much smaller. I guess that the populations of the earlier cities were roughly half the size of those of the later ones, but everything depends on estimates of settlement size and density.

The data from the biggest cities (the Western Zhou capitals at Feng and Hao in the Wei Valley, and the Eastern Zhou capital of Luoyi [later renamed Luoyang]) are poor, restricted largely to elite tombs and hoards of bronzes (Rawson 1999: 393-97; F. Li 2006: 40-49, 62-66; von Falkenhausen 2006: 31-38). The finds at Feng are scattered over roughly 12.5 km^2 and those at Hao across some 6 km^2, but only small parts of these areas would have been built up. At Luoyi we do not even know if the chance finds come from the city of Luoyi itself or represent both Luoyi and Zhengzhou.

Von Falkenhausen (2006: 34) suggests that "the Western Zhou capital in the Plain of Zhou [i.e., the area of Feng and Hao] consisted of a fairly haphazard agglomeration of major religious-cum-residential compounds scattered over an area of perhaps 200 square kilometers, with spacious tracts of agricultural land in between." If this is correct, it implies not only that the population was relatively small, but also that the settlement pattern may have been so dispersed that it is misleading to talk of "cities" at all in early 1st millennium BCE China. This issue also applies to the "cities" of the late 2nd millennium BCE.

That said, there clearly are differences in the density of finds across this 200 km^2, and it seems reasonable to think (as 1st-millennium BCE Chinese authors did) of Feng, Hao, and Luoyi as distinct nuclei, even if they were not exactly "urban" in the sense of having dense, continuous areas of housing (I elaborate on my views on dispersed settlements in Morris 1991: 29-30). I guess at 35,000 residents at Luoyi and Feng around 1000 BCE and perhaps half that many at Hao. I think it is unlikely that Luoyi and Feng had as many as 50,000 residents in 1000 BCE (Chandler's [1987: 460] estimate), given the amount of growth that seems to have gone on in the first half of the 1st millennium BCE; nor that they had fewer than 20,000 residents. I therefore project the biggest Eastern cities growing at a fairly smooth rate, slightly more than doubling in population from about 35,000 people in 1000 BCE to about 80,000 in 500 CE.

700 BCE: Linzi, Luoyi, 55,000 (my estimate); 0.51 points. See under 600 BCE.

800 BCE: Luoyi, Feng, 45,000 (my estimate); 0.42 points. See under 600 BCE.

900 BCE: Luoyi, Feng, 40,000 (my estimate); 0.37 points. See under 600 BCE.

1000 BCE: Luoyi, Feng, 35,000 (my estimate); 0.33 points. See under 600 BCE. Chandler (1987: 460) suggests 50,000 people for Luoyi.

1100 BCE: Anyang, 50,000 (my estimate); 0.47 points. Anyang, the final Shang dynasty capital, has been extensively excavated since 1928, although the walled city at Huanbei was only located in 1997. Huanbei's walls enclose 470 ha, and a population of 20,000-25,000 seems plausible, but other remains at Anyang sprawl across some 30 km^2 (Thorp 2006: 125-71; Chang 1980; Liu and Chen 2010). As in the early 1st millennium BCE (see under 600 BCE), it becomes hard to define where the boundaries of a "city" are in such a dispersed settlement system. My suggestion of 50,000 is therefore somewhat arbitrary; defining the city very narrowly as just the walled area could cut this estimate by 50 percent, while defining it very loosely to include the suburbs could perhaps raise the total to 100,000 or more. Fifty thousand would make Anyang as large as Memphis in 1100 BCE; 100,000 would make it the biggest city in the world in the 13th through 11th centuries BCE. I offer the figure of 50,000 as a sensible middle ground between the very narrow and very loose definitions of the city.

Anyang was founded around 1300 BCE and by 1200 had clearly become a major settlement (however defined). Given the uncertainties of the estimate for 1100 BCE, there seems little point in compounding the difficulties by offering a different estimate for 1200, so I simply propose 50,000 for both dates.

1200 BCE: Anyang, 50,000 (my estimate); 0.47 points. See under 1100 BCE. The walled settlement at Sanxingdui may cover as much as 350 ha (Thorp 2006: 64), and might have been a rival to Anyang for population, but it remains poorly known.

1300 BCE: Zhengzhou, 35,000 (my estimate); 0.33 points. The site of Erligang at Zhengzhou was founded around 1600 BCE and is usually assumed to be an early Shang dynasty capital (Thorp 2006: 62-116; Liu and Chen 2003: 92-99; Liu and Chen 2010). The walled settlement covers 300 ha, but a larger peripheral wall encloses a total of 1,300 ha. As with Anyang (see under 1100 BCE), there are two challenges—first, to define what we mean by "city" in such a case, and second to calculate the density of occupation within the city. Once again, my figure represents a middle ground between a minimalist definition, which might lead to a figure of no more than 15,000 people within the walled core, and a very broad definition, which might come to a number more like 50,000. Zhengzhou seems to have been significantly smaller than 13th-11th century Anyang; my estimate of 35,000 would make it about half the size of contemporary Babylon or Thebes.

1400 BCE: Zhengzhou, 35,000 (my estimate); 0.33 points. See under 1300 BCE. In the absence of detailed evidence, I propose the same figure for Zhengzhou from the 16th through the 14th century BCE.

1500 BCE: Zhengzhou, 35,000 (my estimate); 0.33 points. See under 1400 and 1300 BCE.

1750 BCE: Erlitou, 24,000 (Liu 2006); 0.22 points. Erlitou is much better explored than the sites of 1500-500 BCE, and in phase III covered roughly 300 ha. This estimate—even though Liu (2006: 184) prefers to offer it as merely the midpoint of a range of estimates, from 18,000-30,000—is probably the most reliable prehistoric demographic statistic in the East. The figure of 24,000 represents about 80 people/ha, a low density by the standards of contemporary Western cities like Babylon, but high relative to other prehistoric Chinese settlements.

2000 BCE: Fengcheng-Nanshui, 11,000 (my estimate); 0.1 points. The settlement seems to cover 230 ha (Liu 2004: 111; Liu and Chen 2010: ch. 7), but remains poorly excavated. I assume a low density of 50/ha.

2250 BCE: Taosi, Liangchengzhen, Yaowangcheng, 14,000 (my estimate); 0.13 points. At its height, Taosi covered about 280 ha (Liu 2004: 110; Shao 2005: 91-92); I assume a density of 50/ha. Liu (2004: 240) also comments that the largest chiefdoms of the Longshan period had perhaps 10,000+ members, which might imply that we should use a lower density figure for Taosi (where the remains are, indeed, extremely dispersed, even by the standards of prehistoric Chinese settlements). Recent studies (reported in Liu and Chen 2010: ch. 7) suggest that Liangchengzhen and Yaowangcheng may have been even bigger than Taosi in the second half of the 3rd millennium, reaching 272.5 and 367.5 ha respectively.

2500 BCE: Taosi, Liangchengzhen, Yaowangcheng, 10,000 (my estimate; cf. Liu 2004: 108-110); 0.09 points. Taosi was clearly smaller in 2500 BCE than its later peak, but I am not aware of any good estimates of the difference. See under 2250 BCE.

3000 BCE: Dadiwan, 5,000 (my estimate); 0.05 points. The settlement covers roughly 100ha (Liu 2004: 86-88), and I assume a density of about 50/ha.

3500 BCE: Xipo, 2,000 (my estimate); 0.02 points. The settlement covers roughly 40 ha (Liu 2004: 83), and I assume a density of about 50/ha.

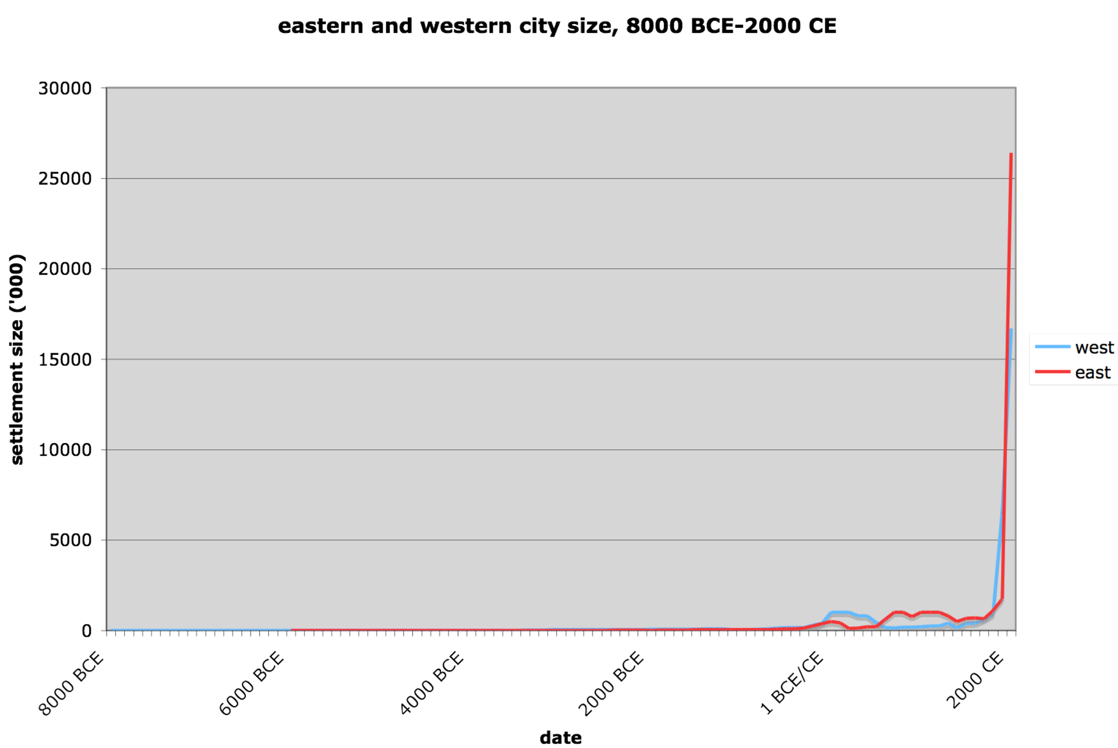
4000 BCE: no settlement seems to have covered a large-enough area to have had a population of 1,000, the minimum number to register on the index (0.01 points). In 4000 BCE Jiangzhai covered 5 ha, but Liu (2004: 79) calculates a density of 44-63/ha, meaning just 220-315 people. Jiahu also covered around 5 ha as early as 6000 BCE, but here too the density was very low. No other site of the 7th through 5th millennia BCE seems to cover more than 2 ha.

[9.4] *City size: discussion*

[9.4.1] *City-size as a proxy measure for social organization*

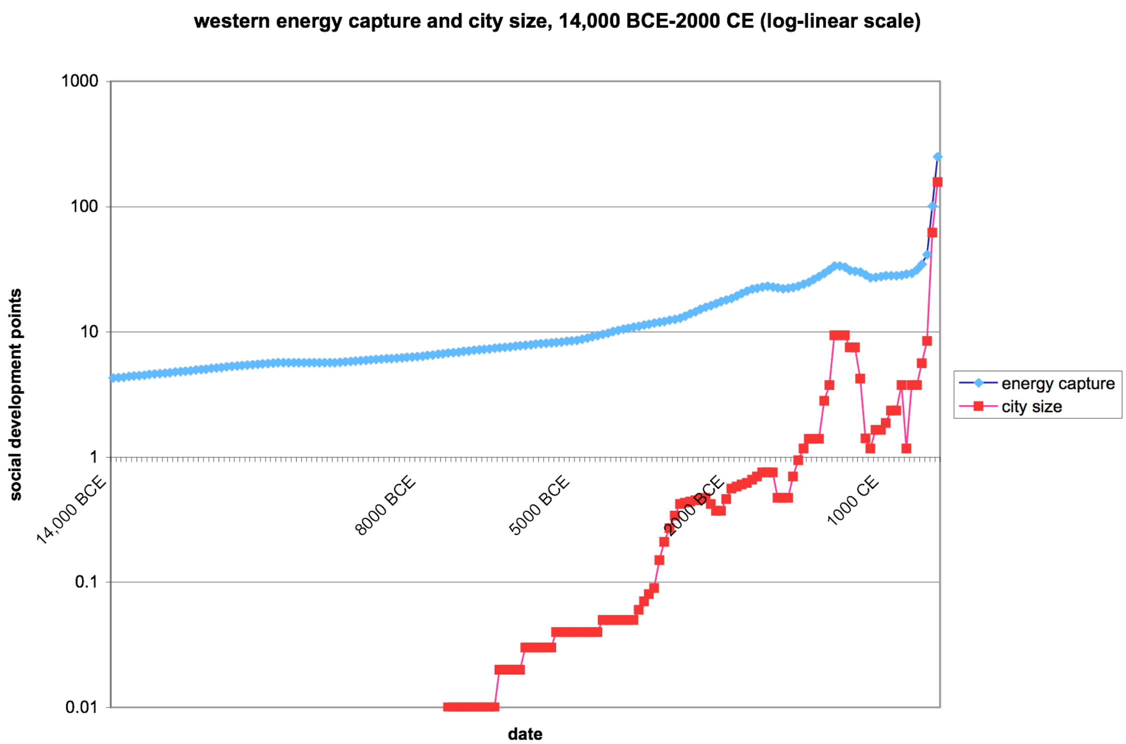
At every point for which we have textual data (beginning in the 3rd millennium BCE in the West and the late 2nd millennium BCE in the East) until the 20th century CE, the largest city in the world was always an administrative center. At the beginning of the textually documented period, Memphis was the capital of Egypt and Anyang was the capital of a Shang dynasty state; in the 19th century CE London was the capital of the British Empire and Beijing the capital of the Qing Empire. And if we press back in time beyond Memphis and Anyang, there is a certain amount of evidence that Uruk in the West and Zhengzhou (and probably Erlitou too) were also the capitals of early states (Morris 2010: 183-84, 207-209). This observation validates the choice of city-size as a proxy for social organization: through most of history, the size of the largest city in a region has been a function of the scale of political organization. In a previously published essay (Morris 2006) I suggested that this was the case in the Greek world of the 1st millennium BCE, and I would now extend this argument to premodern history as a whole. Only in the 20th century CE did economic sources of power trump political sources (in the senses defined by Mann 1986) to such an extent that Washington, DC, the capital of the world's most powerful state, did not rank among the world's 30 biggest cities in 2000 CE, and Beijing, capital of the most powerful state in the East, ranked only 24th (*Economist* 2004: 20). Throughout all previous history, city-size has been a fairly direct reflection of political organizational capacity.

[9.4.2] *City-size/organizational capacity as a function of energy capture*
In very general terms, the shapes of the history of energy capture (Graph 1 on p. 19 above) and city-size/organizational capacity (Graph 32) have a certain amount in common. Both increased very slowly after the end of the Ice Age, accelerating in the last few millennia BCE, and then exploded in the 19th and 20th centuries CE. In both graphs, the Western score is higher than the Eastern for most of the last 10,000 years. However, the differences between the two graphs are just as interesting as the similarities.



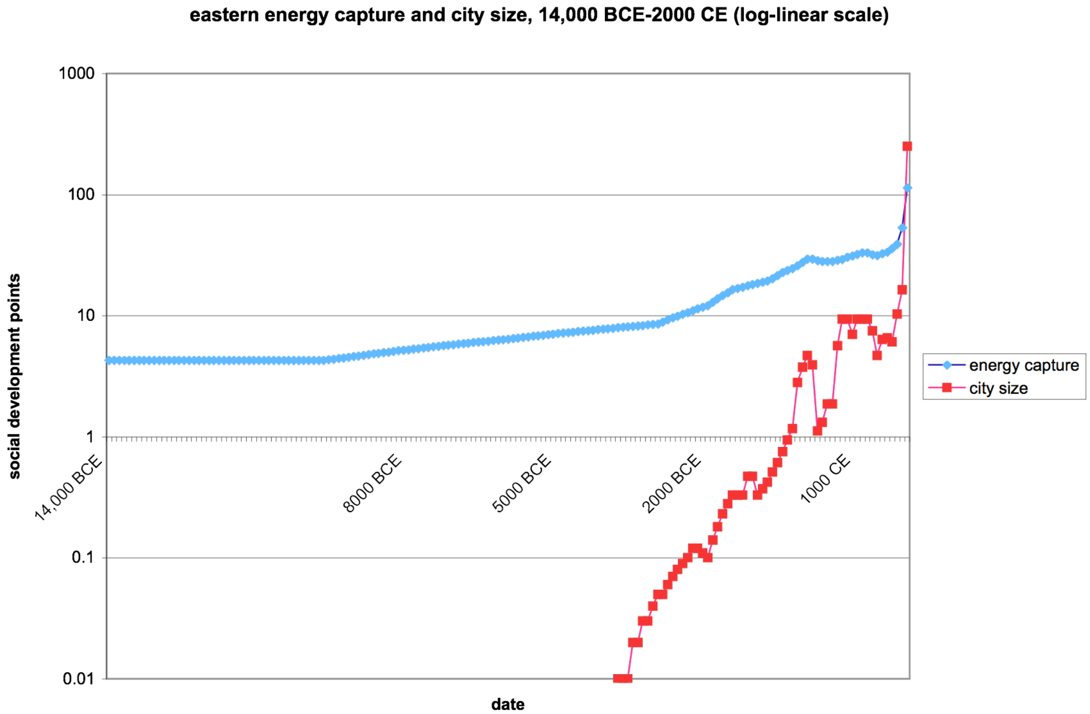
Graph 32. Eastern and Western largest city sizes, 8000 BCE-2000 CE

Graphs 33 and 34 respectively plot Western and Eastern energy capture and city size (expressed in terms of points on the index of social development) against each other on a log-linear scale (graphs 35 and 36 show the same data on a linear-linear scale; the same patterns are visible, though not as sharply as on the logarithmic scale). The most striking contrasts between the energy-capture and city-size curves seem to be (a) that city size starts rising much later than energy capture and (b) that city size is much more volatile than energy capture. Both these contrasts can be explained very easily: city-size is a function of energy capture. Only when a certain level of energy is being captured—somewhere around 7,000-8,000 kcal/cap/day—does the size of the largest settlements start to grow noticeably; but once a community has passed this threshold, relatively small changes at the margin of the energy capture budget have massive consequences for the amount of energy available to organize larger communities.

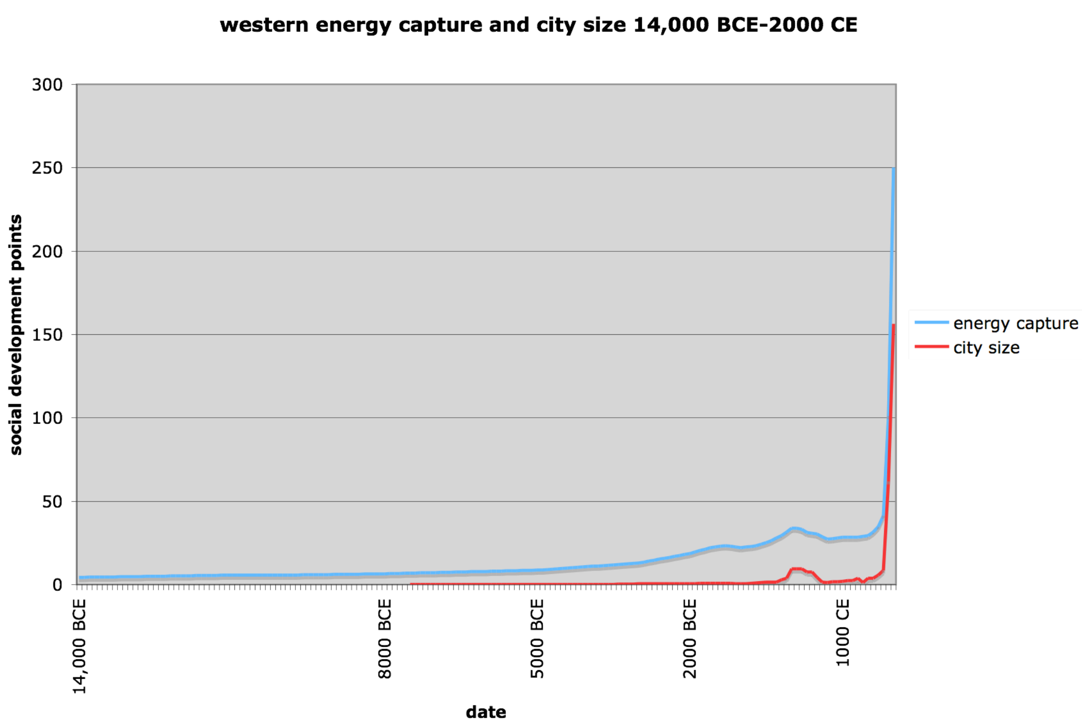


Graph 33. Western energy capture plotted against city size on a log-linear scale, 14,000 BCE-2000 CE, measured in social development points

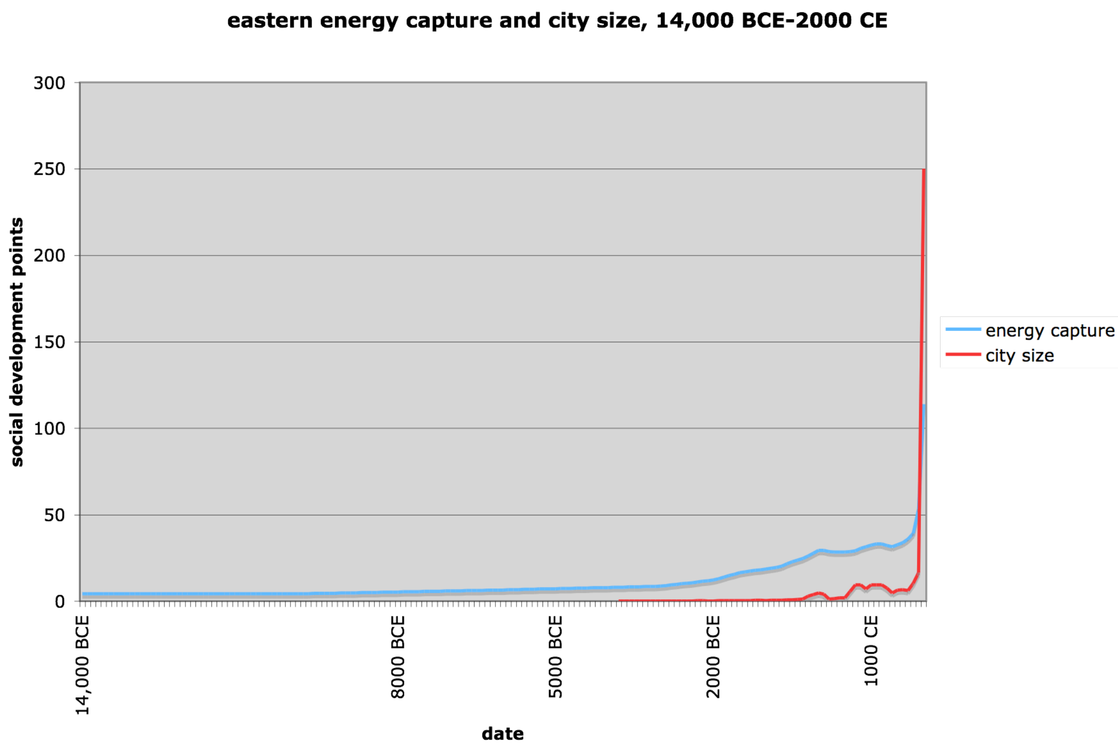
Consequently, both East and West went through similar episodes of initial urbanization when energy capture reached roughly 11,000-12,000 kcal/cap/day (around 3500-3000 BCE in the West and 2000-1500 BCE in the East: Graph 37). Both saw settlement size slump at the end of the 3rd millennium BCE, in the crises associated with the fall of Akkad, Ur, and the Egyptian Old Kingdom in the West and Taosi and the early cities of Shandong in the East (Morris 2010: 190-95, 206-207), even though the crises of these years had only a tiny impact on energy capture in the West or the East.



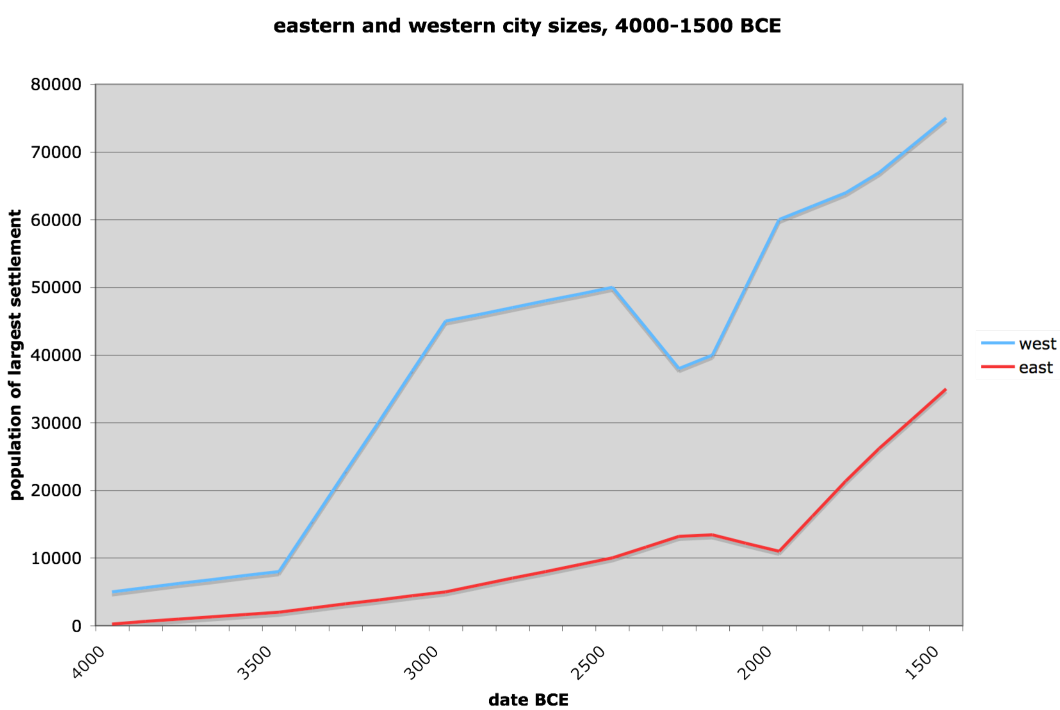
Graph 34. Eastern energy capture plotted against city size on a log-linear scale, 14,000 BCE-2000 CE, measured in social development points



Graph 35. Western energy capture plotted against city size on a linear-linear scale, 14,000 BCE-2000 CE, measured in social development points

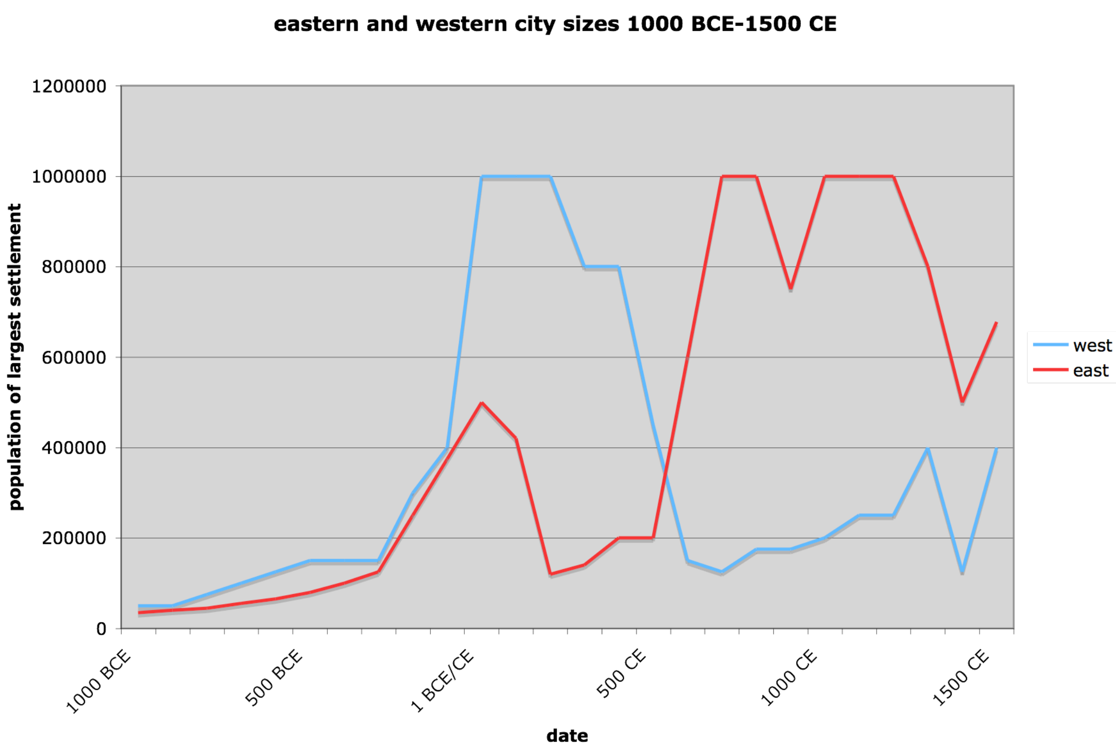


Graph 36. Eastern energy capture plotted against city size on a linear-linear scale, 14,000 BCE-2000 CE, measured in social development points



Graph 37. The size of the largest Eastern and Western settlements, 4000-1500 BCE

The changes in the last 3,000 years have been even more spectacular (Graph 38). In both East and West, the rate of increase in energy capture accelerated in the 1st millennium BCE, but city sizes grew even faster. Once again, there seems to have been a threshold in energy capture, this time a little over 20,000 kcal/cap/day, above which societies created cities of 100,000+ residents; and another threshold, around 27,000 kcal/cap/day, above which super-cities of 500,000 to 1 million people became possible. The great crises of the early 1st millennium CE reduced energy capture in both East and West much more sharply than any previous crisis (by nearly 20 percent between 100 and 700 CE in the West and by nearly 4 percent between 100 and 300 CE in the East), but their impact on city sizes was much greater—Western cities shrank by more than 85 percent between 200 and 700 CE and Eastern cities by more than 75 percent between 1 and 200 CE).



Graph 38. The size of the largest Eastern and Western settlements, 1000 BCE-1500 CE

The East then saw a surge in city-size in the mid- and late-1st millennium CE to rival that of Rome in the late 1st millennium BCE when it had passed through the same 27,000 kcal/cap/day threshold: Eastern energy capture increased by 13 percent between 500 and 1000 CE (from 26,000 to 29,500 kcal/cap/day), but the biggest Eastern cities grew by 400 percent across the same half-millennium (from 200,000 to 1 million residents). The wars that brought down China's Tang dynasty in the late 1st millennium CE barely touched energy capture, but did cause a short-term 25 percent dip in city-size.

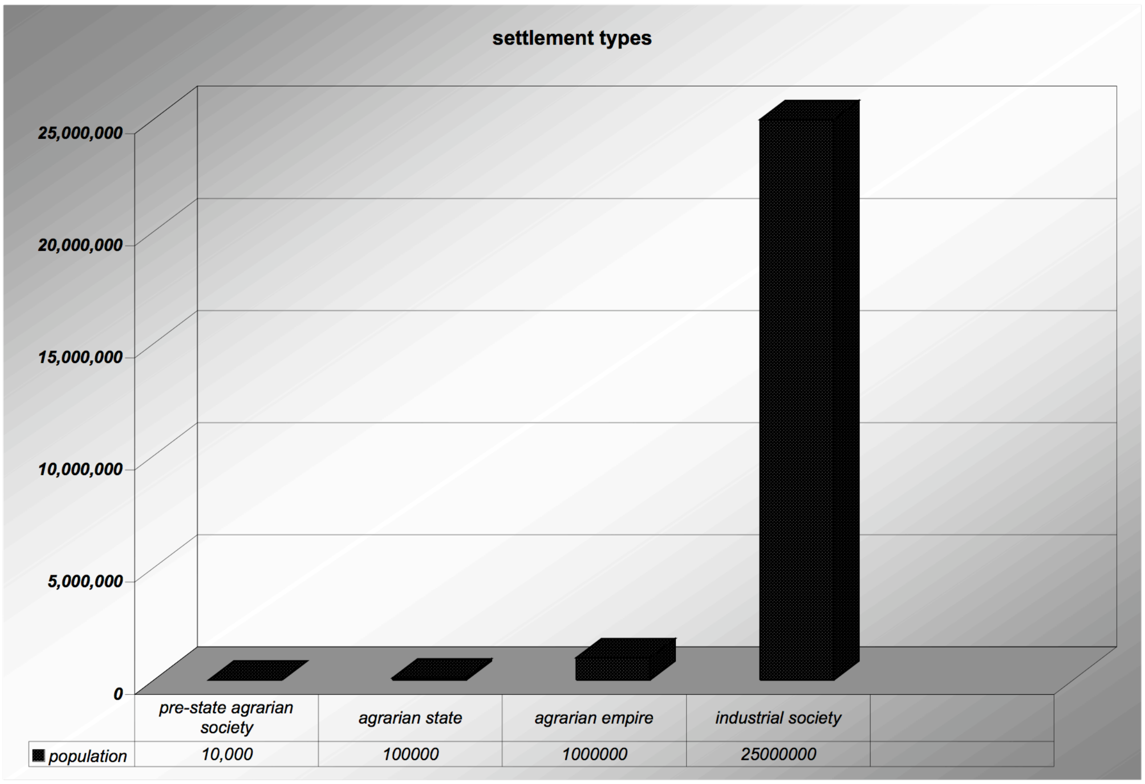
The energy capture: city size relationship continued operating through the 2nd millennium CE. The "Second Old World Exchange" of 1200-1400 CE (Morris 2010: 386-99) drove energy capture down by 5 percent in the East but halved the population of the largest city; in the West it left energy capture untouched but cities shrank by almost two-thirds.

The surge in energy capture since 1500 CE (and especially since 1800) had a predictably dramatic effect on city size. There seems to have been another threshold somewhere around 45,000 kcal/cap/day, which made multimillion-resident cities possible. The great wars of the 20th century devastated the East's biggest cities, but such is the volatility of city-size that Tokyo and Beijing were bigger than ever by the 1960s, while the West's biggest cities (in the Americas) remained entirely untouched by the wars.

[9.4.3] *Magnitudes of city size*

The city-size data also suggest that different levels of social development impose fairly firm orders of magnitude on settlement size. Pre-state agrarian societies (as found in the Western core before 3500 BCE and in the Eastern before 2000 BCE) do not seem to be able to support settlements of more than roughly 10,000 people; agrarian states (which dominated the Western core between the 4th and early 1st millennia BCE and the Eastern core between the early 2nd and mid 1st millennia BCE) do not seem to be able to support settlements of more than roughly 100,000 people; and agrarian empires (which dominated the Western core between the mid 1st millennium BCE and late 2nd millennium CE and the Eastern core between the late 1st millennium BCE and late 2nd millennium CE) do not seem to be able to support settlements of more than roughly 1,000,000 people. Industrial societies, however, can support cities of more than 25 million (graph 39).

The neatness of the premodern orders of magnitude of course depends in part on the roughness of the quantitative estimates (the flat tops on the lines in graph 38 on p. 133 illustrates neatly the vagueness of our knowledge; Rome, Chang'an, Kaifeng, and Hangzhou could just as easily have had 800,000 or 1.2 million residents as the 1 million that the graph ascribes to them). However, the consistency of the results does suggest a hypothesis that would be worth testing against data from other parts of the world—that without the energy windfall provided by fossil fuels, and the associated organizational and technological gains, no one would be living in cities that grew much beyond 1 million residents. We have yet to see what limits our current level of development imposes on settlement size and whether we will transcend those limits (Morris 2010: 590-613).



Graph 39. Largest known settlements and levels of community organization since the Ice Age

10 War-making capacity

[10.1] *Measuring war-making capacity*

The combination of historians' obsession with recording wars, compulsive military record-keeping, artistic patrons' fondness for being portrayed as warriors, the widespread practice of burying dead men with arms and armor, and the archaeological visibility of fortifications means that we are relatively well informed about some aspects of war in many historical contexts. Our problems with quantifying war-making capacity come more from conceptual challenges than from lack of data.

Attempts to measure war-making capacity are as old as war itself; nearly all decisions to go to war involve some kind of assessment of societies' relative military power (even if aggressors regularly overestimate their own strength while defenders regularly underestimate theirs). Comparing war-making capacity between societies in different historical periods or so widely separated by geography that they never come into contact, however, presents much greater problems. Since military capacity is always context-dependent (i.e., armed forces are normally created to fight specific kinds of enemies, under particular geographic and political conditions, and armed forces that do well against one kind of enemy may do much less well against other kinds), comparisons ranging widely across time and space are necessarily much more abstract than similarly broad comparisons of energy capture or city size.

Comparisons of war-making capacity must come down to measuring the destructive power available to societies. By "destructive power" I mean the number of fighters they can field, modified by the range and force of their weapons, the mass and speed with which they can deploy them, their defensive power, and their logistical capabilities. Moreover, these basic facts—which are reasonably well documented for many times and places—must be combined with estimates of less well-documented but equally important factors, such as morale, leadership, and organizational learning ability, as well as the broader parameters of the economy, logistics, ideology, and politics.

The technical problems are daunting, but since the late 19th century wargamers (both military professionals and amateurs) have shown that it is possible to reduce the bewildering complexity of reality to numerical values that can be compared, and have seen their estimates tested against actual conflicts (see, e.g., Perla 1990; Dunnigan 2000).

Wargamers' systems for simulating current and historical wars provide a good starting point, but these approaches rarely attempt to measure and compare war-making capacity across time and space, as required by the index of social development. In principle such transhistorical comparisons should be no different from comparison of actual historical contexts, but in practice the sheer scale of change over time—and the fact that so-called "revolutions in military affairs" are often designed explicitly to produce war-making systems that are simply incomparable with earlier systems—vastly complicates matters. The most famous example is *HMS Dreadnought*, the massively armed and armored battleship introduced by Britain in 1906 with the aim of rendering all previous warships obsolete—only for naval tactics to evolve to fit this new weapon into a system in which older kinds of warships remained important (Massie 1993).

The same is true even of the deadliest modern weapons of all, nuclear arms. Nuclear weapons are of course far more destructive than non-nuclear weapons, but they are not *incomparably* more destructive. The very fact that the force of nuclear weapons is measured in kilotons and megatons—thousands/millions of tons of TNT equivalent—reveals this. The destructive power of nuclear-armed states dwarfs anything in earlier history. In three years of bombing, 1942-45, the US Eighth Air Force dropped 700,000 tons of TNT on Germany; on Halloween, 1961, the Soviet Union tested a single bomb (the so-called "Tsar Bomba") with a yield equivalent to 50-57 million tons of TNT. By 1966 a single Soviet SS-9 Model 2 missile could carry a warhead equivalent to 25 million tons of TNT, more than 30 times the power of the bombs the USA dropped on Germany in World War II; and by the 1970s the USSR had deployed 255 of these ICBMs (Sakharov 1990: 215-25; D. Miller 1998: Appendix 8; De Groot 2005).

Nevertheless. The destructive force of nuclear weapons does remain measurable on the same scales as conventional weapons, just as the poisoning effects of radioactive fallout can be measured in rads and compared with the smaller poisoning effects of chemical and biological weapons (D. Miller 1998: 75-76). And like the Dreadnought-class battleships built after 1906, nuclear weapons have been fitted into broader war-making systems that continue to rely on weapon-types (albeit in much more effective forms) that were in use before 1945. Nuclear war is unthinkable but not unmeasurable (e.g., Glasstone and Dolan 1977; Daugherty et al. 1986; Levi et al. 1987/88).

The biggest difficulty in measuring war-making capacity for the index of social development is in quantifying the relationship between the armed forces of 2000 CE and those of earlier periods. The leap in capacity between 1900 and 2000 was so enormous that it is difficult to measure, and similar difficulties, though on a less enormous scale, also apply to the leap between 1800 and 1900.

On the one hand, this means that if we assign the maximum 250 points on the scoring system to the West in 2000, there will be a wide margin of error in percentage terms in estimates of war-making capacity in 1900, let alone in 1800 or any earlier period. On the other hand, because the gulf between modern destructive power and that in earlier periods is so enormous, the pre-1800 CE scores will be tiny, meaning that in terms of actual points on the social development index the margins of error will also be tiny. As we will see, no war-making system before 1600 CE merits even 0.2 points (i.e., less than one-thousandth of the contemporary score), and very few before 1500 CE even reached 0.1 points. War-making capacity, like city size/social organization, is a function of energy capture, surging upward with relatively small changes on the margin once energy capture reached 100,000 kcal/cap/day. The main contribution that measuring war-making capacity makes to the social development index is to underline the vast gulf separating industrialized 20th- and 21st-century societies from all previous societies.

[10.2] *Western war-making capacity*

[10.2.1] *The 20th-century transformation*

There are many assessments of modern Western military power, but the differences between them are relatively small. I rely mainly on the Institute for International Strategic Studies' (http://www.iiss.org) annual *Military Balance* volumes, which provide data on national spending, force strengths, quality, and logistics. Rikhye et al. 2010 (http://www.globalsecurity.org) is an excellent, up-to-date electronic resource.

Even before the post-September 11th buildup began, the United States' military power dwarfed all rivals. In 2000 CE the West earned the full complement of 250 points. Plenty of other nations had more men and women under arms than the US, and Russia's nuclear arsenal was roughly twice as large as the US's (Norris and Kristensen 2006: 66), but American advantages in every other dimension of war-making hugely outweighed these imbalances. American troops were far better equipped and supplied than those of any other nation, and were better trained and led than those of most nations. They were also vastly more mobile, with America's 11 carrier battle groups completely dominating the world's oceans and the US Air Force doing the same in the skies. US nuclear warheads and launch vehicles were also more reliable and generally more powerful than the Russian.

The greatest difficulty in quantifying war-making capacity comes as soon as we move back from 2000 to 1900. Data on Western European armed forces in 1900 are good, and easily available, but calculating a score for the West 1900 relative to the West in 2000 is very difficult, because the gap between the military systems is so enormous (I draw here primarily on Cleator 1967; Gundmundsson 1993; Hogg 1992; International Institute for Strategic Studies 2001; Ireland and Grove 1997; P. Kennedy 1987).

Armies were bigger in 2000 than in 1900, although not dramatically so (the biggest army in 2000, China's People's Liberation Army, had about 2.25 million active troops and 1.2 million reservists; the biggest in 1900, Russia's, had 1.16 million of all classes). In some respects the basic weapons were also similar—the British Lee-Enfield rifle, introduced in 1895, had an accurate range of about 500 m and a muzzle velocity of 733 meters/second, while the M16 rifle (introduced in the US Army in 1963 but still the normal weapon in modified forms in 2000) is accurate at 550-800 m and has a muzzle velocity of 948 m/s. However, the similarities are dwarfed by the differences: the M16 can discharge 700-950 rounds per minute, while the Lee-Enfield normally managed 20-30 (the record, under test conditions, was 38 rounds/minute). An ordinary M16 or Kalashnikov AK-47 (Chivers 2010) shoots faster than the best heavy machine guns of 1900 (the Maxim gun managed just 450-600 rounds/minute). The first weapon vaguely equivalent to an M16 or AK-47—the German MP18 sub-machinegun—was not introduced until 1918.

Military historians normally date the advent of modern artillery to the "French 75," introduced in 1897. This was a 75 mm rifled cannon with a long recoil mechanism that avoided having to relay the gun after each shot. The gun could fire at the astonishing rate of 15 shells per minute, with a range of 7.5 km. More complex modern artillery fires much more slowly, and the US Army's newest howitzer—the 155 mm M777, introduced in 2005—only manages 2-5 rounds/min; however, the titanium gun is so light it can be airlifted, has a range of 24-30 km, and when used with Excalibur GPS ammunition has a circular error probable at 24 km of just 5 m (i.e., 50 percent of the shells will land within 5 m of the target). The revolution in guided weapons since the 1980s has made each modern cannon worth dozens of 1900-era guns, and advances in mechanization of transport, communications, and electronic warfare have been equally spectacular (Boot 2006).

On the seas, the greatest weapons in 1900 were new steel-armored steam-powered battleships (the word battleship was first used in 1892), typically displacing 15,000-17,000 tons, sailing at 30 km/h (16 knots), and carrying 4 x 12" guns that could hurl a 400 kg shell nearly 23 km. After 1906 the dreadnoughts added heavier armor and six more 12" guns and raised speeds to 21 knots, and after 1911 navies shifted from coal to oil, but the disparity between these ships and contemporary American *Nimitz*-class nuclear-powered aircraft carriers (displacing 100,000 tons, with a top speed of 56 km/h [30 knots], able to go 20 years without refueling, and carrying 90 aircraft with a strike range of more than 700 km) is again enormous.

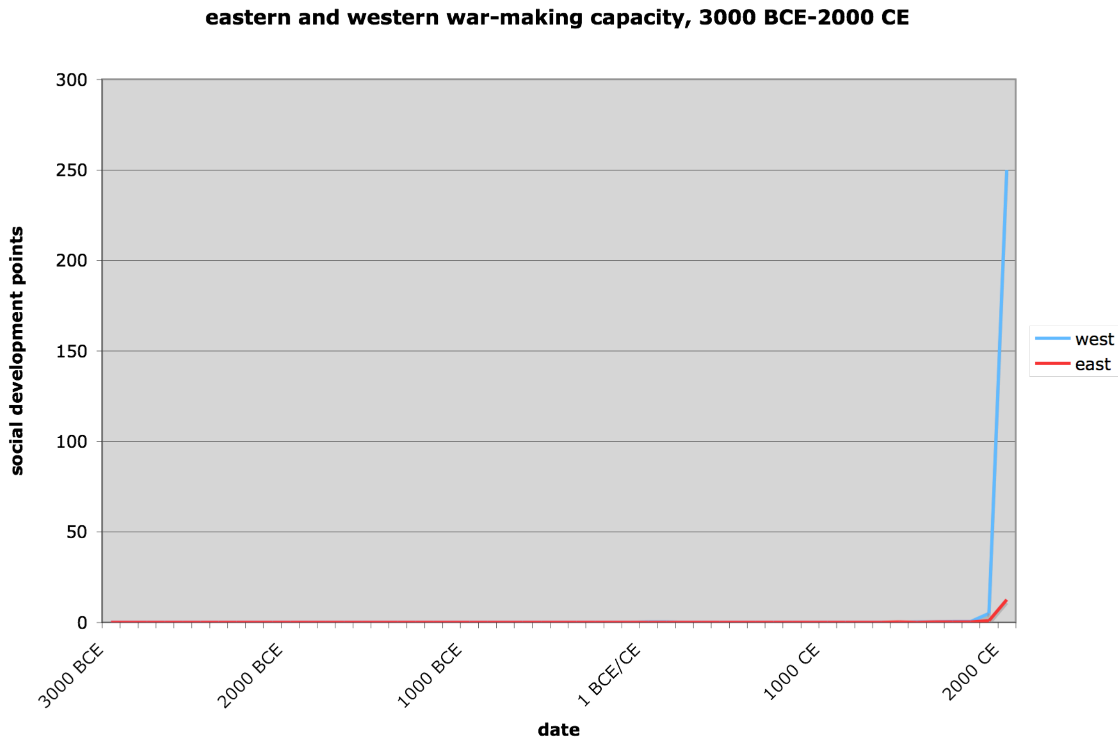
The 20th-century revolution in aerial warfare has been the most astonishing. The first military use of a plane was in 1911, when Italy used bombers and reconnaissance flights against Turkey. The gulf between these early efforts and the most sophisticated military planes in 2000 (e.g., the B-2 stealth bomber, introduced in 1989, with a range of 11,000 km and a cruising speed around 900 km/h, virtually undetectable, able to penetrate almost any anti-aircraft defense and to deliver GPS guided munitions or more than 10 MT of nuclear weapons) is breathtaking.

We can easily compare the amount of firepower, speed and range of maneuver, and countless other dimensions of the armed forces of each period. It is commonly suggested, for instance, that the power of artillery increased twenty-fold between 1900 and 2000 and that of antitank fire sixty-fold between 1918 and 2000; but putting a concrete score on the full range of changes across the 20th century is much more difficult. In *Why the West Rules—For Now* (Morris 2010: 633) I suggest a ratio of 50:1, meaning that Western war-making capacity scored 5 points in 1900 (as against 250 in 2000), but that is no more than a guesstimate.

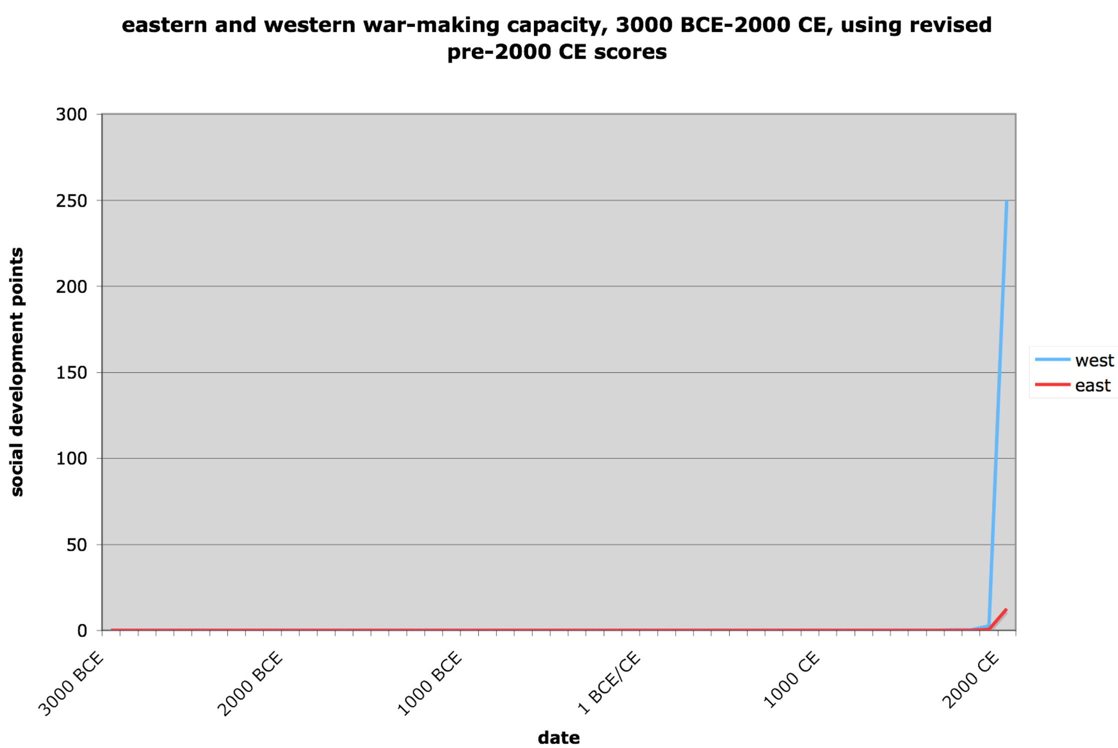
I suspect that my guesstimate probably lies somewhere in the middle of the plausible range of figures for war-making capacity in 1900. A ratio of 100:1 is probably just as plausible, producing a Western score of 2.5 in 1900. This margin of error—50 percent—is much higher than what I suggest for the social development index as a whole (Morris 2010: 640-43), but the enormous gap between the Western war-making score for 2000 CE and the scores for all earlier periods means that we can easily halve all pre-2000 scores without making any discernable difference to the index. Table 8 and Graph 40 show Eastern and Western war-making scores since 4000 BCE using the numbers I have estimated; Graph 41 also shows the scores if we reduce all pre-2000 CE estimates by 50 percent.

Table 8. War-making capacity since 4000 BCE (in social development points)

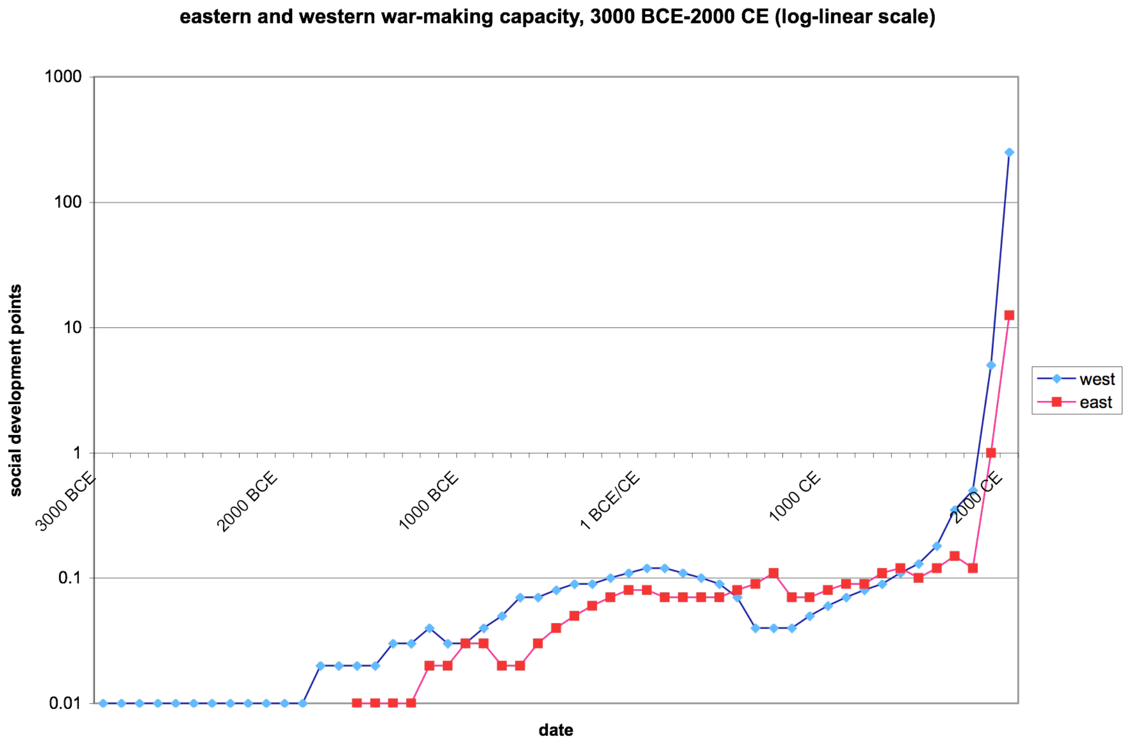
	West	East
4000 BCE	0	0
3000 BCE	0.01	0
2500 BCE	0.01	0
2250 BCE	0.01	0
2000 BCE	0.01	0
1750 BCE	0.02	0
1500 BCE	0.02	0.01
1400 BCE	0.03	0.01
1300 BCE	0.03	0.01
1200 BCE	0.04	0.02
1100 BCE	0.03	0.02
1000 BCE	0.03	0.03
900 BCE	0.04	0.03
800 BCE	0.05	0.02
700 BCE	0.07	0.02
600 BCE	0.07	0.03
500 BCE	0.08	0.04
400 BCE	0.09	0.05
300 BCE	0.09	0.06
200 BCE	0.10	0.07
100 BCE	0.11	0.08
1 BCE/CE	0.12	0.08
100 CE	0.12	0.08
200 CE	0.11	0.07
300 CE	0.10	0.07
400 CE	0.09	0.07
500 CE	0.07	0.08
600 CE	0.04	0.09
700 CE	0.04	0.11
800 CE	0.04	0.07
900 CE	0.05	0.07
1000 CE	0.06	0.08
1100 CE	0.07	0.09
1200 CE	0.08	0.09
1300 CE	0.09	0.11
1400 CE	0.11	0.12
1500 CE	0.13	0.10
1600 CE	0.18	0.12
1700 CE	0.35	0.15
1800 CE	0.50	0.12
1900 CE	5.00	1.00
2000 CE	250.00	12.50



Graph 40. Eastern and Western war-making capacity, 3000 BCE-2000 CE

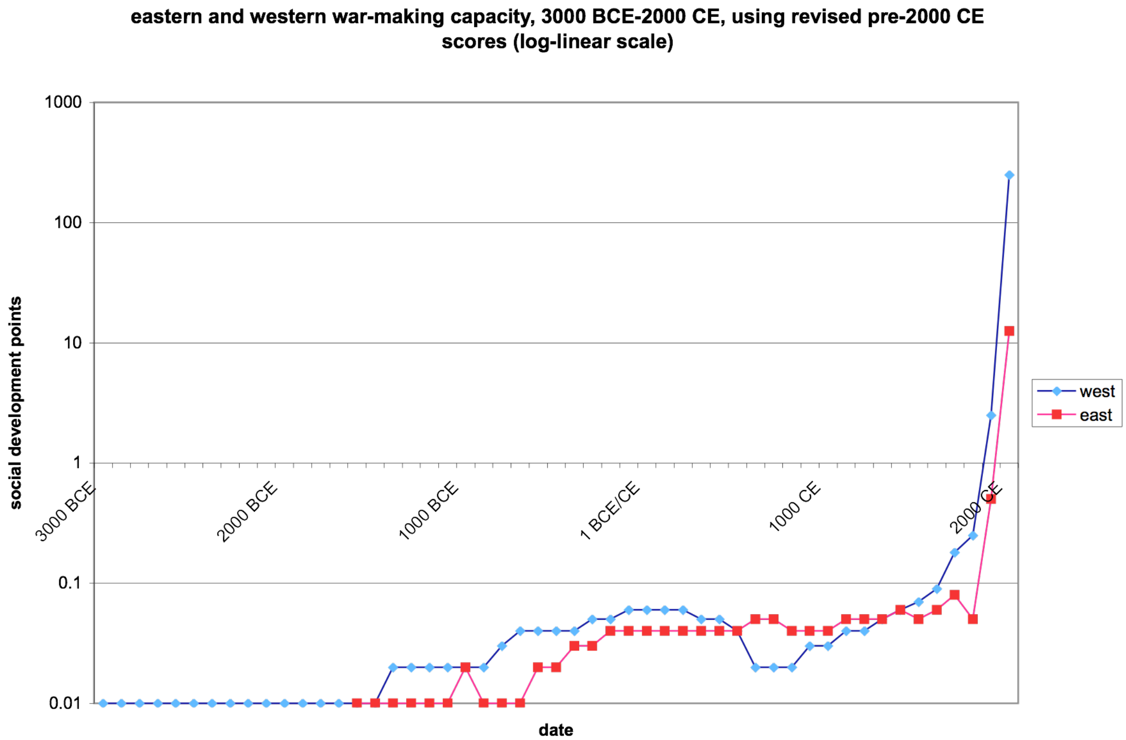


Graph 41. Eastern and Western war-making capacity, 3000 BCE-2000 CE, increasing all scores before 2000 CE by 50 percent



Graph 42. Eastern and Western war-making capacity, 3000 BCE-2000 CE, plotted on a log-linear scale

A logarithmic scale of course makes the differences easier to see, and so Graph 42 shows the scores I have calculated on log-linear axes and Graph 43 represents the revised numbers (i.e., with reduced scores for all periods before 2000 CE) in the same way. The revised figures of course make the boom in destructive power in the 20th century twice as big as my figures, but other than increasing the modern/premodern contrast, the main consequence of halving the pre-2000 CE scores is to make the East-West differences between 100 BCE and 200 CE too small to measure (as opposed to my estimates, representing the Roman Empire as having slightly greater war-making capacity than the Han Empire). The conclusion must be that any reasonable estimate of the ratio of war-making capacity in 2000 CE to that in 1900 CE—whether we set it at 50:1, as I have done, at 100:1, or just 25:1—makes little difference to the larger social development index.



Graph 43. Eastern and Western war-making capacity, 3000 BCE-2000 CE, plotted on a log-linear scale and increasing all scores before 2000 CE by 50 percent

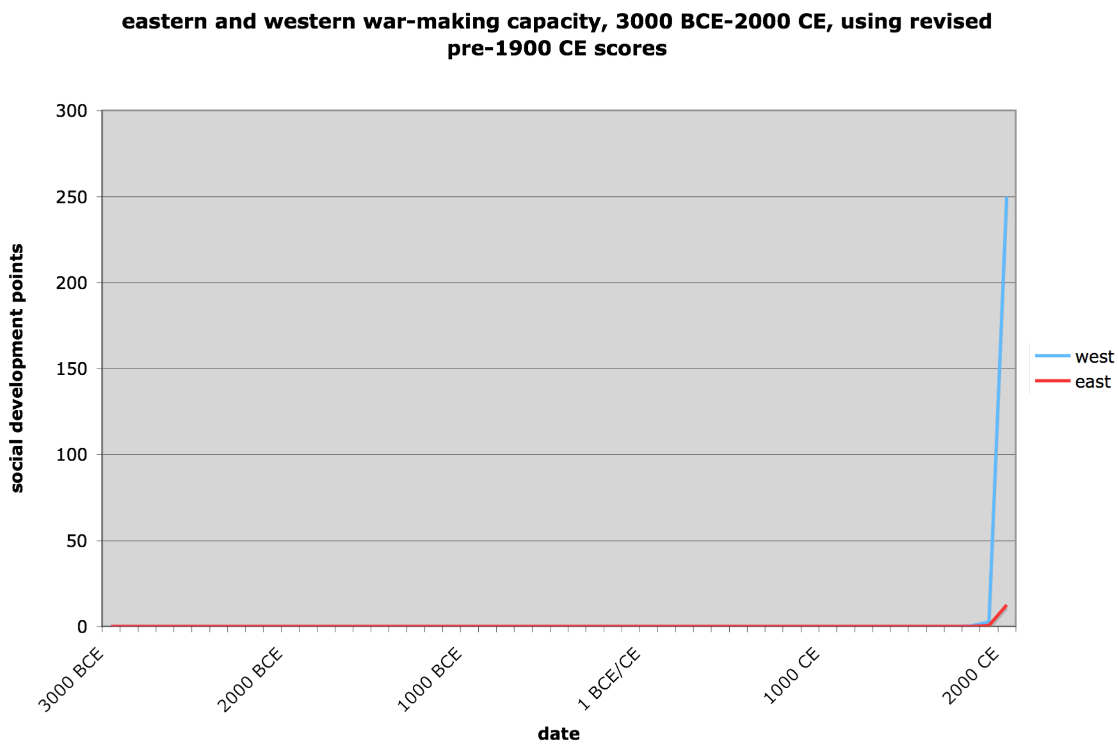
[10.2.2] *The European military revolution, 1500-1800 CE*

The leap in Western war-making capacity between 1800 and 1900 CE was nowhere near as great as that between 1900 and 2000, but it was nevertheless enormous. The ranges and accuracy of weapons, their speed of firing, the force of projectiles (magnified by the invention of explosive shells), the size of armies, the speed of transport, and the scale of logistics, often increased by an order of magnitude across the 19th century (I draw here primarily on Bertaud 1988; Black 1998, 2006; Bruce et al. 2008; D. Chandler 1966; Esdaile 2007; Harding 1999; McNab 1999; G. Parker 1996; Rodger 2004; Rogers 1995; Rothenberg 1978, 2006; Q. Wright 1965: 232-33).

The French introduction of the *levée en masse* in the 1790s pushed army sizes up toward 500,000—about half the size of the biggest armies in 1900—but the principal weapon, the smooth bore musket, was far less effective than the rifles of 1900. Even well trained Napoleonic infantry could only get off about 4 shots per minute. Muskets could shoot up to 400 m, but at ranges more than 50-75 m they were so inaccurate that individual fire was virtually useless; and even when fired at less than 75 m, only masses of volleying men had much chance of hitting their target. In one 18th-century exercise, fewer than half the musketeers firing at a target 30 m wide at a range of 60m managed to hit it (Chase 2003: 74).

Smoothbore cannons, particularly 12-pounders that could fire 4-6 rounds per minute and were effective at ranges up to 500 m, were starting to become the dominant arm on battlefields in 1800 (e.g., Hollins 2003), but they remained far less effective than the rifled cannons of 1900; and flat-trajectory explosive shells did not become common until the 1850s.

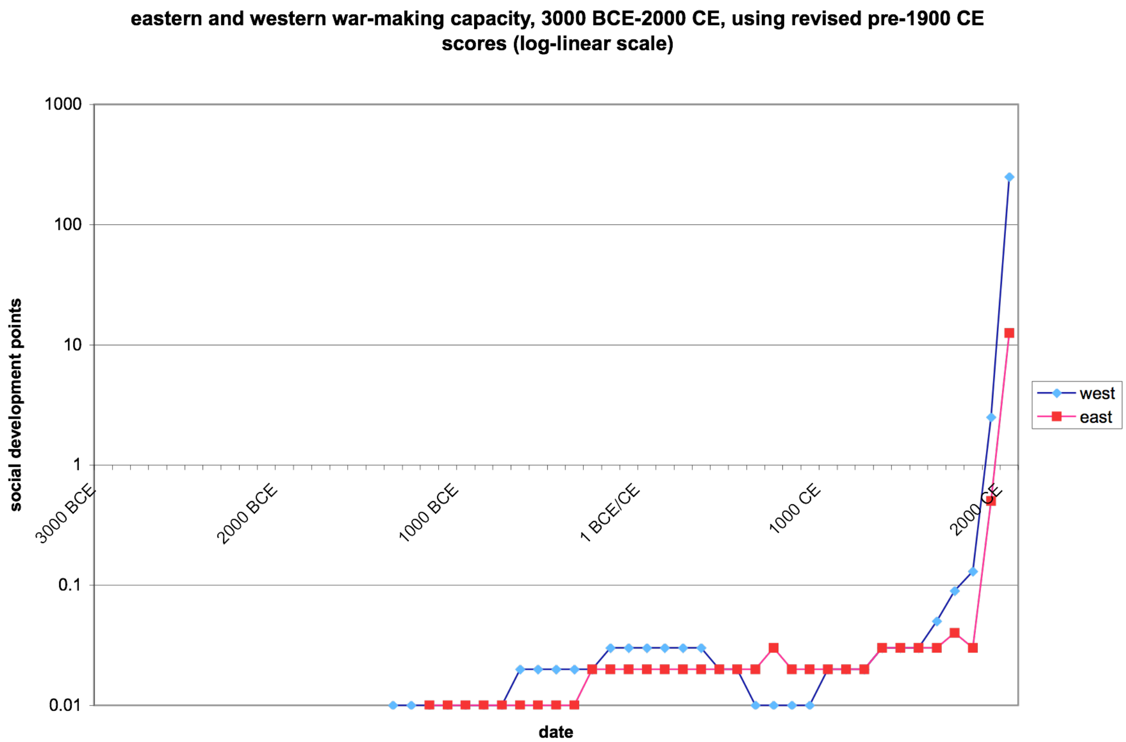
The best warships in 1800, like *HMS Victory* (launched 1765), could manage 8-9 knots (15-17 km/h) with a good wind, but were much slower in bad weather. The *Victory* carried 104 cannons, totaling roughly 1 ton of solid shot, with a range of up to about 2 km (Henry 2004). The disparity between this and pre-dreadnought battleships with their steel armor, steam engines, explosive shells, and torpedoes is again glaring.



Graph 44. Eastern and Western war-making capacity, 3000 BCE-2000 CE, reducing scores before 1900 CE

Once again reducing the complexity of military systems to a single score is a highly subjective exercise, but I suggest a ratio between Western war-making capacity in 1900 and in 1800 of roughly 10:1, producing a score for 1800 of 0.5 points. This guess could be just as wide of the mark as my guess for 1900 (or as a Napoleonic musket-shot), and the true ratio could easily be 20:1. If I have overestimated war-making capacity relative to 2000

CE for both 1800 and 1900, instead of scores of 250 points for 2000, 5 points for 1900, and 0.5 points for 1800, we could conceivably get scores of 250 points for 2000, 2.5 points for 1900, and 0.13 points for 1800, producing the results we see in Graphs 44 (linear-linear) and 45 (log-linear). But even the now greatly reduced pre-1900 CE scores make only a minuscule difference to the social development index as a whole, because the absolute numbers involved are so tiny.



Graph 45. Eastern and Western war-making capacity, 3000 BCE-2000 CE, plotted on a log-linear scale and reducing scores before 1900 CE

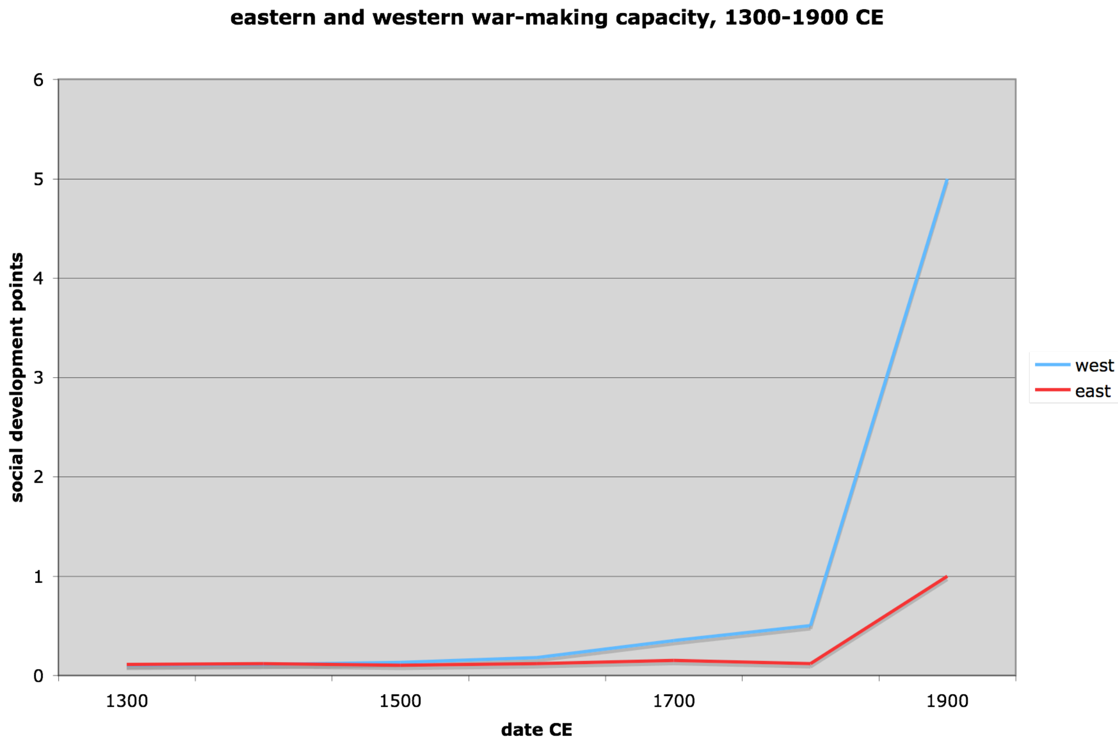
Since the pioneering work of Michael Roberts (1967: 195-225, reprinting a lecture originally given in 1955) and above all Geoffrey Parker (1996; originally published 1988), the period 1500-1800 has come to be known as the "European military revolution," characterized by enormous increases in the size, efficiency, firepower, and reach of armies and navies. Compared with the changes between 1800 and 1900, those during the military revolution were actually very small, but they nevertheless left the war-making capacity of medieval European societies far behind.

Improvements in firearms and organizational changes within societies to exploit these improvements account for much of the military revolution. Gunpowder weapons reached Europe in the 1320s, but 100 years passed before they began to be important on battlefields on land and sea (I draw here primarily on Black 1998, 2002; Chase 2003; Duffy 1996, 2006; Glete 2000; Jörgensen et al. 2006; Lynn 1989, 1997, 1999; Nosworthy 1990; G. Parker 1996; K. Roberts 2010; Rogers 1995; van Creveld 2004). Even in 1500, musketeers' rate of fire was measured in minutes per round, not rounds per minute, and their guns were effective only at very short ranges. Particularly in England, some soldiers wondered whether longbows—which, in trained hands, could discharge 10 arrows per minute and were accurate up to 200 m—might not still be superior weapons, and on the steppes, where cavalry were much more important, bows did continue to dominate the battlefield well into the 17th century.

Early matchlock muskets did throw projectiles heavier than bows, but their main advantage was that they called for very little skill compared to what an archer needed to learn. Massed musketeers could, under the right circumstances, defeat bows and pikes, as they showed in the Italian Wars at Ravenna (1512), Marignano (1515), and Bicocca (1522). As early as 1490 Venice decided to replace its crossbows with guns, and by the 1560s the English fondness for longbows was looking decidedly anachronistic. By 1594 Dutch armies had introduced line tactics and volleys, greatly increasing their effectiveness (albeit at the cost of requiring much more training and supervision), and in the 1630s Gustavus Adolphus showed just how powerful the new approach could be.

Flintlock firing mechanisms sharply increased the rate of fire during the 17th century, and in the 18th century socket bayonets allowed musketeers to double as pikemen. Artillery advanced even faster. Cannons had already made medieval stone fortifications obsolete by the time of Charles VIII's invasion of Italy in 1494, but by the mid-17th century intricate earthworks had restored the defensive advantage.

Organizational advances in the later 18th century—particularly the French invention of column attacks and divisional structures on land and British tactical innovations at sea—further improved the performance of armed forces, but the biggest changes were organizational. France, the strongest West European state, could muster 40,000-50,000 troops for war in 1500; 80,000 in 1600; 400,000 in 1700; and 600,000 in Napoleon's invasion of Russia in 1812. Fleets grew more slowly, with the British (the strongest), Spanish, and Russian all roughly doubling their numbers of ships of the line between 1700 and 1800, while the French fleet actually shrank after Louis XIV's plan to invade England collapsed in 1689. At the beginning of this period, Ottoman Turkish armies and fleets were the strongest in the West; by its end, the balance of power had shifted decisively toward Western Europe.



Graph 46. Eastern and Western war-making capacity, 1300-1900 CE

Converting this complicated mass of information into single scores for Western war-making capacity again involves very subjective guesstimates, but despite their revolutionary nature, the changes between 1500 and 1800 were clearly much smaller than those between 1800 and 1900 (let alone those between 1900 and 2000). I suggest that Western war-making capacity increased roughly 50 percent in the 16th century, 100 percent in the 17th century, and another 50 percent in the 18th century, for a total fourfold increase during the whole period of the military revolution (as opposed to my estimates of a tenfold increase during the 19th century and a twentyfold increase during the 20th century). Working backward from the figure of 0.5 points suggested for 1800, these estimates produce rough figures of 0.35 points for 1700, 0.18 points for 1600, and 0.13 points for 1500 (Graph 46).

[10.2.3] *From Caesar to Suleiman, 1-1500 CE*

Most general military histories seem to agree that Western war-making capacity generally declined in the first half of this long period and then recovered in the second half (e.g., Delbrück 1975-85; J. F. C. Fuller 1957; Gat 2006; Keegan 1993. Bachrach 2005, covering 500-1300 in Geoffrey Parker's *Cambridge History of Warfare*, is a partial exception, stressing continuity and devoting only a few pages to declining capacity before c. 750).

Going into more detail, there seems to be at least some consensus that military power began declining after 200 CE and accelerated after 400, languishing between 600 and 800 and then recovering slowly, with the recovery accelerating after 1300. There is little sign of a post-Black Death slump in the 14th century to compare with those in energy capture and city size.

Yet although there were important changes on the battlefield, such as the rise of heavy cavalry as bigger horses and stirrups became available and the increasing effectiveness of mounted bowmen in Muslim armies, the tactical continuities between 500 CE and 1300 CE (and indeed across the whole two millennia between 700 BCE, by which time iron weapons and cavalry were in general use) are even more striking (Bachrach 2005; Gat 2006). The basics—iron weapons, metal armor, combined infantry and cavalry tactics, archery, siege machinery, oar- and wind-powered ships—changed rather little across this long period, and the real changes were logistical and organizational.

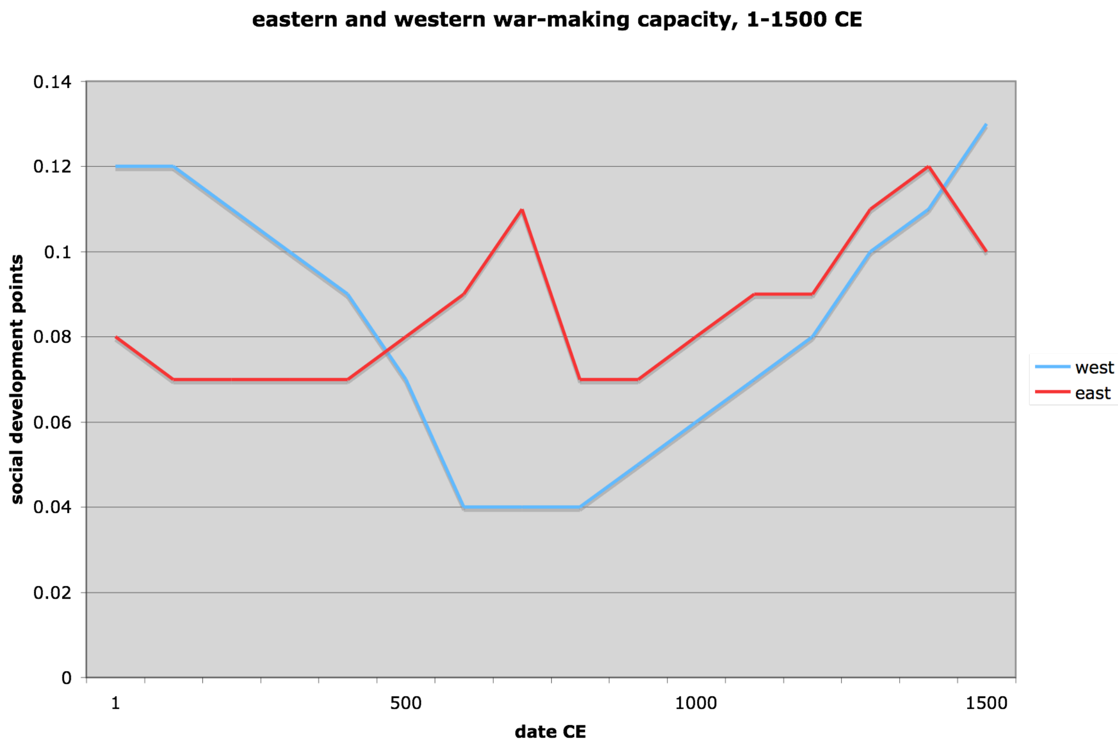
In the 30s BCE the Roman Republic had roughly 250,000 men under arms, organized into devastatingly effective legions, supported by the most extraordinary logistical system in the premodern world, and led (much of the time) by outstandingly professional officers and NCOs (from an enormous literature, I have benefited particularly from D. Campbell 2003; J. B. Campbell 1994; Erdkamp 2007; Goldsworthy 1996, 2003; Roth 1999).

After the crises of the 3rd century CE the army expanded, probably reaching around 500,000 men c. 350 CE (I follow A. D. Lee 2007: 74-79 on this controversial topic). There is also much controversy about the quality of the late Roman army, with some historians suggesting that the real issue was that the nature of the mission changed. There was a shift toward defense-in-depth rather than frontier defense (Luttwak 1976), and consequent changes in organization, with a growing distinction between garrison and field armies, with the latter using smaller units and more cavalry than the early imperial army, and with all forces relying more on immigrant troops (see, e.g., Elton 1996; A. D. Lee 2007; Ward-Perkins 2005; Luttwak 2009).

Yet while some older claims (e.g., Macmullen 1963) about the ineffectiveness of the garrison troops may have been overstated, Roman military capacity probably declined seriously (though not catastrophically) between the time of the "Antonine Plague" in the 160s CE and the battle of Adrianople in 378. Between Adrianople and Khusrau II of Persia's invasion of the Byzantine Empire in 609 CE, the size and fighting power of Western armies fell very seriously, driven by a combination of declining population and crumbling administrative structures. By the 7th century armies had shrunk to a few tens of thousands of men, and the rapid Arab conquest of the Persian and much of the Byzantine Empires owed more to the collapse of imperial structures than to any great military strength on the caliphs' side (Haldon 1990, 1999, 2007, 2008; Kaegi 1992, 2003; H. Kennedy 2001; Luttwak 2009).

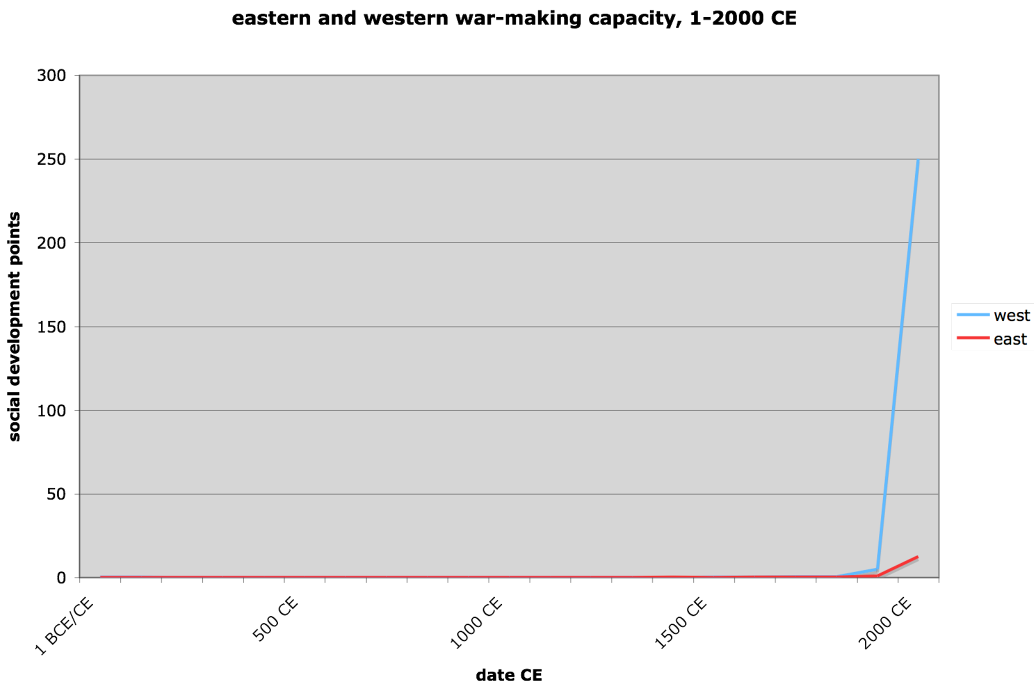
Throughout the Western Middle Ages armed forces remained tiny, disorganized, and poorly supplied (Haldon 2005; International Medieval Logistics Project (http://www.medievallogistics.bham.ac.uk), rarely reaching one-tenth the size of imperial Roman forces and never coming close to matching Roman effectiveness. Medieval European armies have been intensively studied (e.g., Bennett et al. 2005; Bradbury 2007; Contamine 1984; Keen 1999; Rogers 2010; Verbruggen 1977), but the less thoroughly researched Byzantine (Haldon 2008; I. Heath 1979, 1995; McGeer 2008; Nicolle 1992) and particularly Muslim forces probably remained more powerful through most of the period c. 630-1500, especially after armies of Turkic mounted archers tens of thousands strong became common (e.g., Basan 2010; Fodor 2009; Freely 2008). Western European crusaders managed to take Jerusalem in 1099, and Byzantine armies regained some lost territory, but on the whole the advantage lay with the Turks in the 10th through 15th centuries. In 1527 the Turkish sultan Suleiman the Magnificent claimed to be able to muster 75,000 cavalry (mostly archers) and 28,000 infantry with guns, plus field artillery, and despite his failure to take Vienna in 1527, Turkish armies remained the most powerful in the West throughout the 16th century, and arguably some way into the 17th. Similarly, despite its famous defeat at Lepanto in 1580, the Turkish fleet remained a serious rival for Christian fleets well after 1600 (Anglim et al. 2003; Black 1998; Books 2009; Imber 2002: 252-318; Murphey 1999; Rose 2002).

Reducing this history to scores for war-making capacity again involves abstracting from the specific missions each armed force faced, but some basic conclusions seem reasonable. The biggest Western armies in 1500 CE were still much smaller than those available in late Republican or early imperial Rome, and did not begin to match the Romans' technical sophistication; but the growing power of firearms (especially against fortifications, and especially in combination with large field armies of light cavalry, such as those of Ottoman Turkey) makes me suspect that the military power available to Suleiman had finally regained the level of that available to Caesar. If the war-making score for the West in 1500 was 0.13 points, a score of 0.12 points seems reasonable to me for the year 1 CE. If the consensus is correct that Roman military capacity remained high until the 4th century then declined sharply, we might estimate scores of 0.1 points in 300 CE, tumbling to just 0.04 in 600, on the eve of the Arab conquests, reviving to 0.08 by 1200, and then climbing more quickly to 0.13 in 1500 (Graph 47). (Historians who feel that the Roman score should be a little higher (say, 0.13 or 0.14 points) or a little lower [scores anywhere between 0.10 and 0.14 points seem perfectly plausible] should adjust the scores for 300-1200 CE accordingly.)

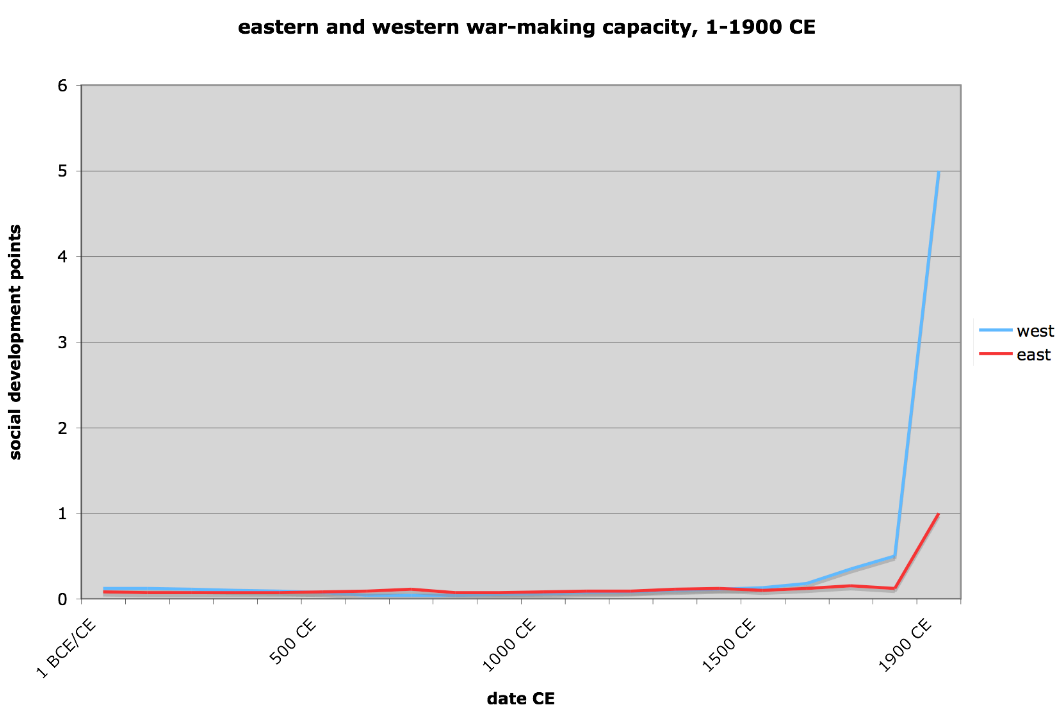


Graph 47. Eastern and Western war-making capacity, 1-1500 CE

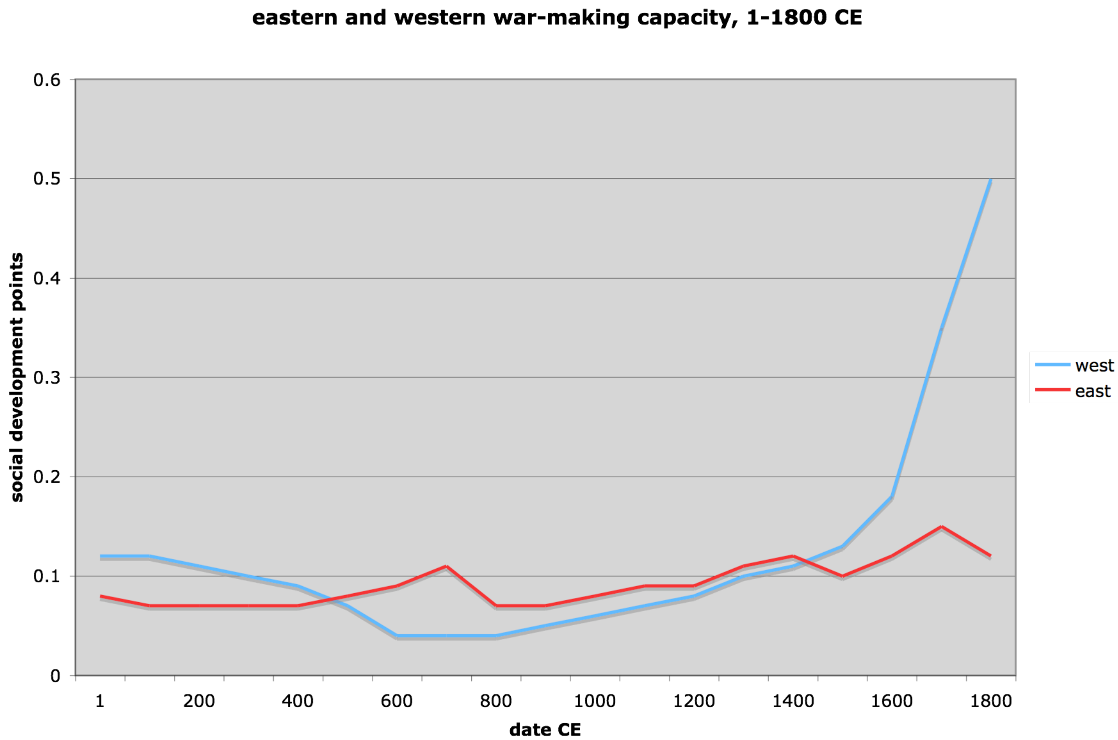
These numbers seem to me consistent with the qualitative assessments in the historical literature. They also, however, involve all kinds of abstractions and subjective judgments, which rival observers might choose not to accept. That said, Graph 48 shows what is perhaps the most important point: all premodern scores for war-making capacity, including those for Caesar's and Suleiman's times, are so tiny that no conceivable adjustment would make much difference to the social development index. And this is not just an artifact of the extraordinary level of military power in 2000 CE; as Graph 49 shows, even judged from the perspective of 1900, the changes in Western military power between the 1st and 8th centuries CE are still too small to see. Only when we look back from the perspective of 1800 (Graph 50) can we see serious differences in the earlier scores. Even if we were to double the scores for 600-800 CE, or to decide that Roman war-making capacity was only surpassed in 1600 rather than 1500 CE, it would make little difference.



Graph 48. Eastern and Western war-making capacity, 1-2000 CE



Graph 49. Eastern and Western war-making capacity, 1-1900 CE



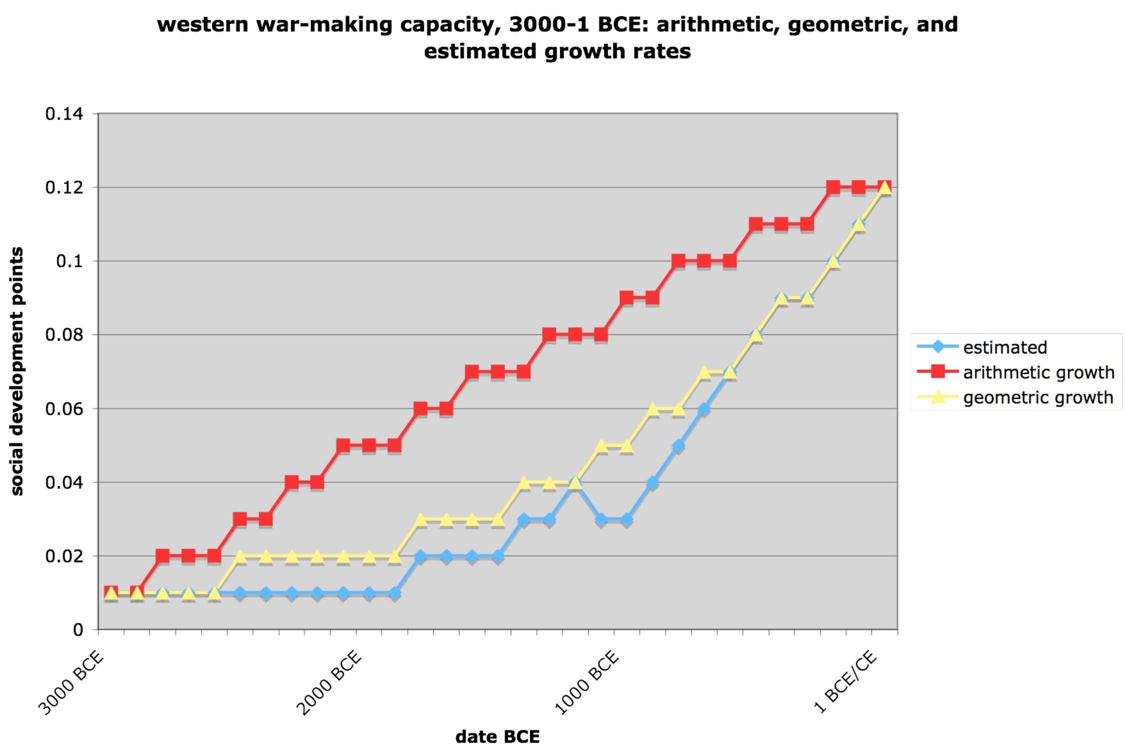
Graph 50. Eastern and Western war-making capacity, 1-1900 CE

[10.2.4] *Early warfare, 3000-1 BCE*

The last three millennia BCE, taking us from the age of Narmer in Egypt to Augustus in Rome, saw a huge increase in war-making capacity (there are many general reviews of ancient warfare; those I have found particularly helpful include Anglim et al. 2003; Beal 1992; Darnell and Manassa 2007; de Graeve 1981; de Souza 2008; Drews 1988, 1992; Gabriel 2002; Hamblin 2006; Hanson 1989; Lawrence 1965, 1996; Littauer and Crouwel 1981; Miller et al. 1986; E. F. Morris 2005; Philip 1989; Raaflaub and Rosenstein 1999; Sabin et al. 2008; Shaw 1991; Spalinger 2005; Wachsmann 1998). Among the main battlefield advances in this long period we might list were the replacement of stone by bronze weapons across the 3rd millennium BCE, the rise of heavy infantry by 2500, the spread of horse-drawn chariots around 1600, the replacement of simple (self) by composite (reflex) bows probably around the same time, the replacement of bronze by iron weapons after 1100, the introduction of cavalry after about 900, the spread of the trireme after 700, the rise of phalanx tactics by 600 and their successive improvements, the introduction of torsion catapults and bigger ships (quadriremes, quinqueremes) after 400, the improvement of fortifications around 300, and the development of more flexible infantry tactics by 200.

We can compile a similar list of advances for organization (e.g., the first known standing army around 2350 BCE, the establishment of professional charioteers around 1500, the rise of tax-based standing armies after 750 and of full-time fleets after 500, Roman innovations in recruitment after 400), and force sizes show a similar upward path, from the 5,400 men that Sargon of Akkad boasted about c. 2350 BCE, through the roughly 30,000 infantry and 5,000 chariots that fought on each side at the battle of Kadesh in 1274 and the 100,000 men who marched with Shalmaneser III of Assyria in 845, to the hundreds of thousands (the precise numbers are debated) raised by Persia to invade Greece in 480 and by Rome and Carthage to man their fleets in the 260s-240s.

Graph 51 shows three ways of representing war-making capacity in the period 3000-1 BCE numerically. By scoring pre-3000 BCE war making at zero I am not signaling support for the fashionable anthropological view that pre-state societies were peaceful places; that theory has been decisively falsified (see especially Keeley 1996). The zero score is a purely technical issue, reflecting the fact that too little destructive force was available to communities making war to register on the social development index.



Graph 51. Three ways of estimating Western war-making capacity, 3000-1 BCE

We could certainly start from other assumptions, for instance setting scores at zero until the first standing army we hear of in 24th-century BCE

Mesopotamia. There is no obvious reason to favor one of these assumptions over the others. I start with 0.01 points in 3000 BCE simply because it is a conveniently round number, but no other plausible assumption would make any discernible difference to the social development index.

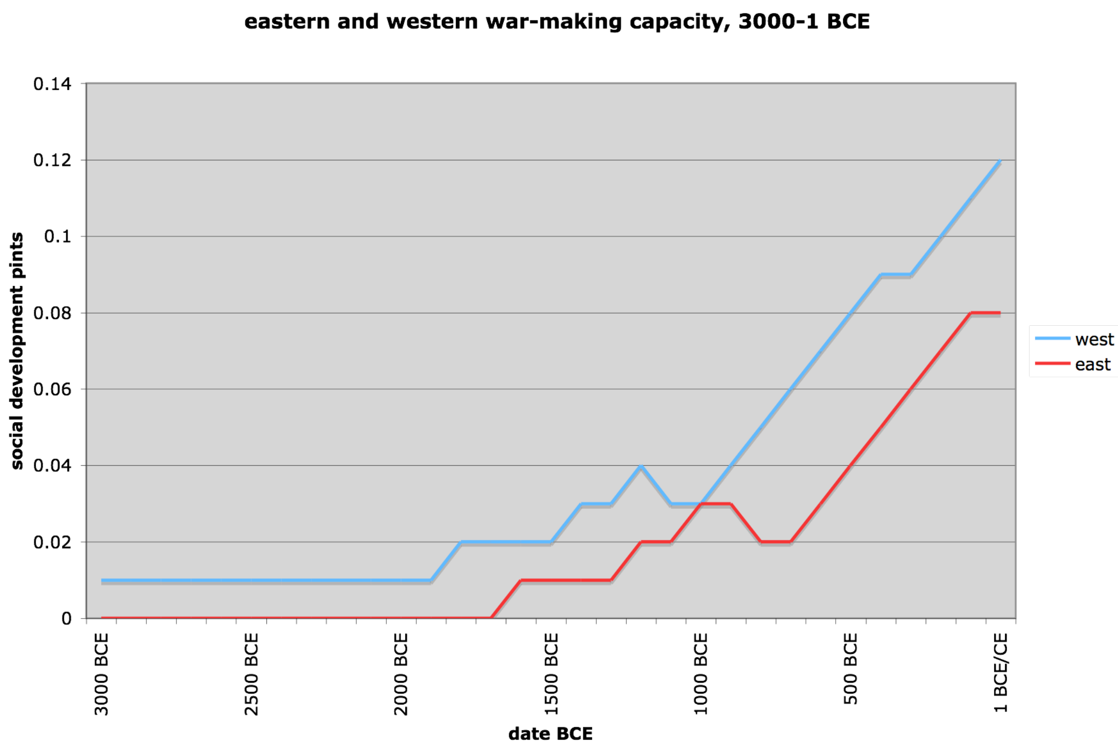
The red line in Graph 51 shows war-making capacity rising by simple arithmetic steps from 3000 to 1 BCE; the yellow line, by geometric steps (i.e., at a steady rate of increase of 8.65 percent per century); and the blue line shows my estimates for the rate of change. (The arithmetic and geometric curves do not rise smoothly from 0.01 points in 3000 BCE to the 0.12 points calculated for 1 BCE; because the numbers involved are so tiny and the minimum step is 0.01 points, the lines inevitably move up in jerks.)

Arithmetic growth clearly does not correspond to reality. It would mean that by 2200 BCE the armies of Sharkalisharri of Akkad and Pepy II of Egypt (which had bronze and even some stone weapons, almost no armored infantry, no chariots or cavalry, and only simple fortifications: Hamblin 2006), scoring 0.04 points, were already as powerful as those of the Umayyad and Abbasid caliphates (which had iron weapons, reflex bows, cavalry and camel corps, and sophisticated qasrs: H. Kennedy 2001); and that by 1300 BCE the army of Ramses II was as strong (0.08 points) as that of Justinian in the 6th century CE. Neither of these conclusions is plausible.

The geometric curve seems more believable, although it surely oversimplifies reality by glossing over the collapse of 1200-1000 BCE. The collapse of 2200-2000 BCE also had a serious impact on war-making capacity, but the scores are again so small in that period (just 0.01 points) that the decline cannot be registered on the graph unless we assume that in 2100 BCE Mesopotamian and Egyptian war-making had reverted to pre-state, pre-bronze levels, which does not seem likely. My estimated growth rates diverge from the geometric simplification is positing a slower takeoff in the 3rd millennium, a decline (from 0.04 to 0.03 points) in the 1200-1000 BCE "dark age," followed by a faster increase in the early 1st millennium BCE. (The scores for 400 and 300 BCE on both the geometric and estimated curves are identical [at 0.07 points] not because there were no military developments—this century took war-making from the hoplites and triremes of the Peloponnesian War to the combined-arms tactics and quinqueremes of Alexander and Carthage—but because of the rounding of very small numbers; the scores in 400 BCE are just big enough to round up to 0.07, while those in 300 BCE are not quite big enough to round up to 0.08.)

The geometric and estimated curves both imply that war-making capacity in the 13th century BCE, when the kings of the International Age seemed well on the way to turning the East Mediterranean into a single large empire, was at roughly the same level (0.04 points) that it would fall back to in 600-800 CE, when the Byzantine and Sassanian Persian Empires fell apart and the Arab conquerors took over their former territories. The estimated curve also implies that ancient war making regained this level around 900 BCE, when Assyrian kings like Adad-Nirari II were also building up large empires. In *Why the West Rules—For Now* (Morris 2010: 195-200, 233-37, 343-63) I argue that these are all plausible conclusions. Finally, my estimates also suggest that Roman war-making capacity between 200 BCE and 200 CE compared closely with that in the West between 1300 and 1500 CE—a suggestion that late medieval Europeans probably would have found believable.

Graph 52 shows my estimates for war-making capacity in the last three millennia BCE.



Graph 52. Eastern and Western war-making capacity, 3000-1 BCE

[10.3] *Eastern war-making capacity*

[10.3.1] *The East-West military balance in 2000 CE*

The greatest military power in the East in 2000 CE was the People's Republic of China, but while it is easy enough to obtain approximate figures for its military strength (e.g., International Institute for Strategic Studies 2001: 346-51; Norris and Kristensen 2006), it is much more difficult to decide how many social development points to award Eastern war-making capacity in 2000 CE relative to the West's 250 points.

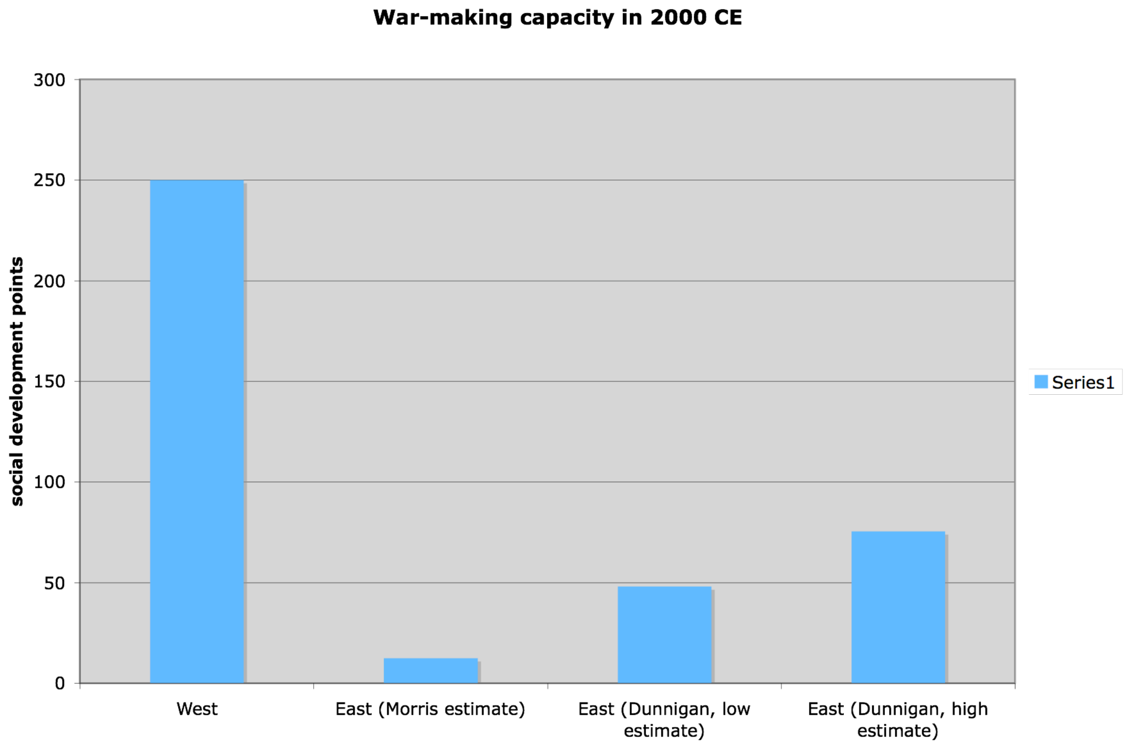
In 2000 the United States outspent China more than 20:1 in market exchange rates and more than 9:1 at purchasing power parity rates, and outnumbered it more than 25:1 in nuclear warheads, more than 10:1 in intercontinental ballistic missiles, 14:1 in nuclear-armed submarines, and 11:0 in aircraft carrier battle groups. In numbers of main battle tanks the two armies were roughly equal, but the quality of America's tanks was far higher than that of China's, and in every other arm—from trucks to helicopters—the United States had overwhelming superiority. In general technological capacity, the US lead was even greater. Western military dominance was certainly not total, and analysts regularly doubted whether American forces would dare to confront directly the masses of Chinese submarines and surface-to-surface missiles based in the Taiwan Straits; but China had little ability to project military power beyond its immediate surroundings, while the United States bestrode the rest of the world like a colossus (e.g., Ferguson 2004).

In 2000 CE Western war-making capacity was clearly much higher than the East's (see, e.g., Kaplan 2005), but how much higher? I know of very few attempts to boil it down to a single score. In his book *How to Make War*, wargame designer James Dunnigan (2003: 624-44) assigned "combat power" scores to different nations. He gave separate scores for land and sea power, ranking the United States first in both categories. On land the US scored 2,488 points, and China, which placed second, scored 827 points. On sea the United States scored 302 points, and China, which ranked fifth, scored 16 points (Britain ranked second, with 46 points; Russia third, with 45 points; and Japan fourth, with 26 points). If we follow the technique I use in the social development index of focusing only on the most developed region in East and West, Dunnigan's figures would give a West: East ratio for war-making capacity in 2000 CE of roughly 3:1 on land and 19:1 at sea. If we add together the land and sea scores we get 2,790 points for the United States and 843 points for China (3.3:1); if instead we weight land and sea power equally, converting the United States' score in each category to 125 points to add up to the same 250-point system that I use here, China scores 48.17 points (41.55 on land, 6.62 at sea), producing a West: East ratio of a little over 5:1.

Dunnigan does not explain how he arrived at his scores, but a West: East war-making capacity ratio of roughly 3:1-5:1 clearly involves assuming diminishing returns to investment, given that the US outspent China between 9:1 and 21:1 in 2000 CE. It also weights mass over sophistication, given that the United States' dominance is much greater in complex, technology-intensive weapons such as ICBMs, anti-missile systems, stealth bombers, precision-guided munitions, and aircraft carriers than in simple weapons such as assault rifles and grenades (how much of a lead the US retains in electronic warfare remains to be seen).

The difficulties the United States and its allies have had in defeating low-tech enemies in Iraq and Afghanistan suggest that these assumptions have merits, but there is also some evidence that these difficulties owe at least as much to strategic and doctrinal missteps as to inherent limitations on Western war-making capacity (see, e.g., S. Jones 2009; R. North 2009; Packer 2005; Ricks 2006, 2009). Other military analysts (e.g., T. Adams 2008; Boot 2006; P. Singer 2009) suggest that there are in fact increasing returns to investment, and that the "Revolution in Military Affairs," driven by improved information processing and accuracy of delivery systems, has already transformed war-making as dramatically as (and much faster than) the early-modern European "military revolution." The extraordinary one-sidedness of the battles against Iraqi conventional forces in 1991 and 2003 (Boot 2006: 318-418; Gordon and Trainor 2006) suggests that this perspective also has merits. The Revolution in Military Affairs seems to have transformed the ways conventional interstate wars are fought, dramatically increasing the West's lead in war-making capacity over the rest of the world, but it has had much less impact on occupying and pacifying defeated nations (cf. Nagl 2002).

I suggest a West: East war-making capacity ratio for 2000 CE of roughly 20:1, much higher than Dunnigan's range of 3:1-5:1. This would be by far the highest West: East war-making ratio in history, dwarfing even those of the 19th and 20th centuries, but the vast technological gap that separated Eastern and Western military forces in 2000 seems to me to justify it. If my estimate is reasonably accurate, Eastern war-making capacity in 2000 earned just 12.5 points on the index of social development, as compared to the West's 250 points. If Dunnigan's estimates are better, in 2000 the East earned somewhere between 48.17 (the "low estimate" in Graph 53) and 75.54 points (the "high estimate").



Graph 53. Alternative quantitative estimates of the East: West military balance, 2000 CE

[10.3.2] *The East's modern military revolution, 1850-2000 CE*

The arrival of modern Western war-making systems in the Pacific in the mid 19th century was the most profound rupture in the history of Eastern military traditions. Eastern armies had been using firearms longer than Western, but had failed to keep pace with Western advances in gunpowder weapons since the 15th century, and in Japan, the extreme case, there had been little fighting and no serious improvements in firearms since the early 17th century (Chase 2003: 193-96).

China and Japan began emulating Western military practices after the arrival of naval expeditions on their shores in 1840 and 1853 respectively, but Japan adapted to the new challenges far more successfully (Spence 1990; Jansen 2000). The government introduced European-style conscription in 1873, reduced the samurai to impotence later in the decade, and then built up its army first on French and then on German lines and its navy on British lines. In 1880 it still lagged very far behind the Western powers, with just 71,000 men under arms (just one-sixth as many as Germany) and a military tonnage of just 15,000 (one-fortieth as much as Britain), but by 1900 it had leapt ahead to 234,000 soldiers (almost half as many as Germany) and 187,000 tons (almost one-fifth as much as Britain) (P. Kennedy 1987: 203).

The quality of Japanese armed forces also improved sharply (Harries and Harries 1991; Evans and Peattie 1997). In 1894-95 they showed mastery of Western military thought, discipline, and organization as well as equipment in crushing Chinese forces; in 1900, Japanese troops played the main part in relieving the diplomatic quarter in Beijing during the Boxer Rebellion; in 1902, Britain concluded that a naval alliance with Japan was the best way to preserve its voice in Pacific affairs; and in 1904-05 Japan won a shattering victory over Russia (even if the war almost drove the country into bankruptcy). Japanese war-making capacity remained much lower than that of any of the major European powers, but it had become a regional power, and probably the only non-Western power in the world that could stand up to European violence (Connaughton 1988; Paine 2003).

Japan's spectacular successes in 1914-15 and 1941-42 were won while the Western powers were heavily distracted in Europe. Japan got most of what it wanted in the Treaty of Versailles (although its demand that the text include a clause insisting on racial equality was defeated), but when it did have to face serious resistance from the United States in 1942-45 (even though the US made the Pacific very much its secondary front) the continuing gap between Eastern and Western war-making capacity was made painfully clear (J. Ellis 1993; Ellis and Cox 2001).

Japan largely demilitarized in 1945 (although by the end of the 20th century its navy was once again a significant regional force), but with the end of its civil wars in 1949 China revived as an East Asian great power. It intervened to great effect (albeit at horrific cost) in Korea in 1950, won a small border conflict with India in 1962, and tested its first atomic bomb in 1964. Training and professionalism in the People's Liberation Army suffered greatly in the 1960s during the Cultural Revolution, however, and while forces on the northern frontier did manage to hold their own in skirmishes with the Soviet Union in 1969 (despite losing roughly 800 dead to the Soviets' 100), in the 1970s serious shortcomings in organization, doctrine, and equipment became clear. The PLA performed poorly in a limited war with Vietnam in 1979 (Elleman 2001: 235-97; Graff and Higham 2002), and Deng Xiaoping launched a modernization program in the same year. Military budgets only began growing significantly in the 1990s, but they quadrupled during that decade and again in the following one. By the 2020s Chinese military spending may catch up with that of the United States. As of 2010, however, the east-west military gulf remains enormous.

Eastern war-making capacity trailed the West's right throughout the 20th century. Japanese forces won notable victories over Western troops in the early 1940s and Sino-Korean and Vietnamese armies also got the better of Europeans and Americans in the 1950s-60s, but in each case the Eastern powers were able to exploit the fact that from a Western perspective these were secondary conflicts to primary struggles within Europe, first against Nazi Germany and then against the Soviet Union (Gaddis 2005; Westad 2005). The East-West gap in war-making capacity narrowed between 1900 and 1940 but remained large, and then grew much wider still across the next sixty years.

Putting a single value on the East-West military ratio in 1900 is less difficult than in 2000. As noted above, in 1900 the German army outnumbered Japans' by more than 2:1 and the British navy outnumbered Japan's nearly 6:1, and in both cases the European forces also had major qualitative strengths. I estimate that the West: East ratio in 1900 was roughly 5:1, which, if Western war-making capacity scored 5.0 points, would mean that the East scored 1.0 point in 1900. Further implications of this would be that Eastern war-making capacity grew 12.5-fold during the 20th century, while Western capacity grew fifty-fold, and that Eastern military power in 2000 was 2.5 times greater than the West's had been in 1900. If, however, we adopt Dunnigan's estimates, which imply that Eastern military capacity scored between 48.17 and 75.54 points in 2000, we would have to accept a correspondingly greater increase (50- to 75-fold) in Eastern war-making across the 20th century.

[10.3.3] *Eastern war-making capacity in the gunpowder era, 1500-1850 CE*

The broad shape of war-making capacity in the East across China's 2,000-year imperial history is reasonably clear (Barfield 1989; di Cosmo 2002a, 2002b; Elleman 2001; Friday 2004; D. Graff 2002; Graff and Higham 2002; Kierman and Fairbanks 1974; Lewis 1990; Lorge 2005, 2008; Perdue 2005; Swope 2005, 2009; van de Ven 2000; Waley-Cohen 2006; Yates et al. 2009). Once again the main challenge is deciding on the precise scores to assign, but in the East the numbers involved (and hence the margins of plausible error) are for most of the period even smaller than those in the West.

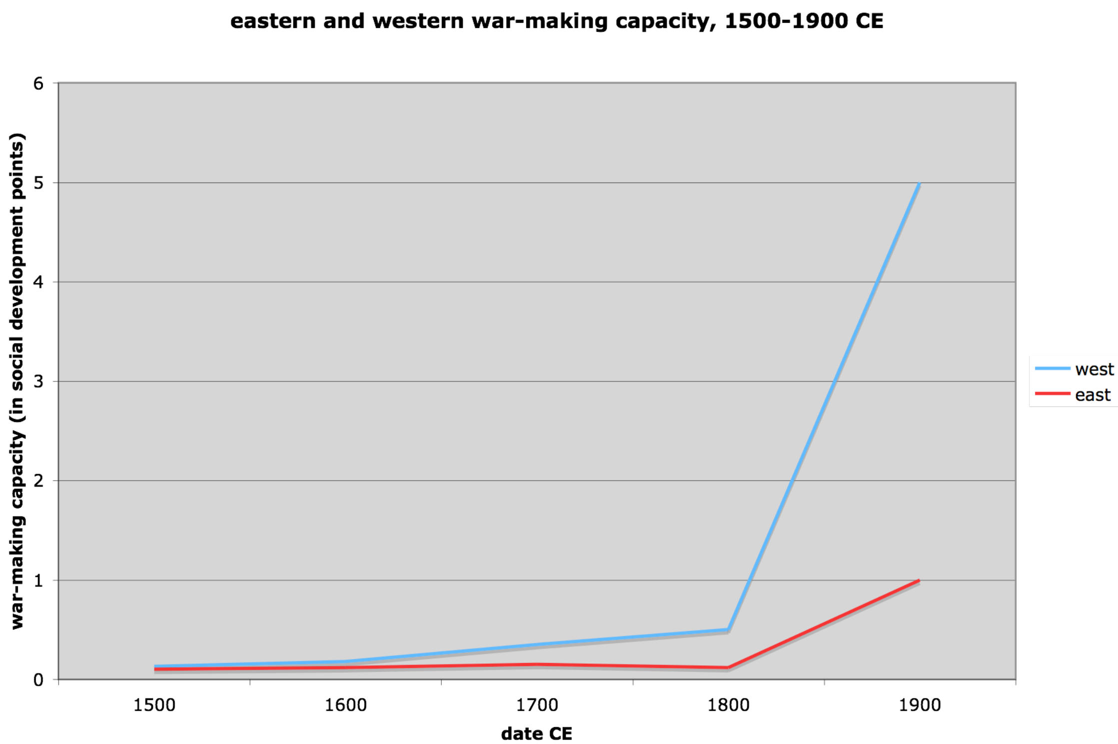
Directly comparing Eastern and Western war-making capacity before 1900 CE is a very rough-and-ready business. The West was clearly much stronger by 1800, and probably already somewhat stronger by 1500, at the start of the Western military revolution. The Ming dynasty could muster large armies when it saw fit (particularly for the steppe campaigns of the first half of the 15th century), but failed to exploit gunpowder technology as effectively as Europeans.

Western guns were widely recognized as superior to Eastern in the 16th century. The Ming government may have had access to a few Western cannons as early as the 1520s, but if so, they remained curiosities until the 1540s. By then Japanese armorers were producing very effective copies, although these too remained rather scarce. Even the celebrated "Qi's Army" that turned the tide in the mid-16th century pirate wars featured very few musketeers compared to contemporary European armies (R. Huang 1970). Their guns were often amateurishly made and tended to explode, which discouraged gunners from getting close enough to their weapons to aim them properly (So 1975: 15-36). Qi's Army never numbered above 10,000 troops, and had more impact on naval warfare than on the vast Ming army. Qi's new naval arrangements were desperately needed; the Ming navy had declined spectacularly since the early 15th century (Lo 1958a), and much desperate scrambling was required to create the force that cooperated with Korean ships to hold off Japan in the 1590s. The same was true of the land forces. The garrison of Beijing, for instance, only shifted from clay cannonballs to lead in 1564, moving on to iron (like the Europeans) in 1568, and only in the 1570s did Qi Jiguang introduce light cannons on carts protected by wicker barriers, like those the Hungarians had used against the Ottomans at Varna in 1444.

Ming war-making capacity was certainly much weaker than that of the Habsburg Empire in the 16th century and in some ways weaker than that of the tiny Dutch Republic too. I suggest a score of 0.12 for the East in 1600 CE (as compared to 0.18 for the West), at the time of Hideyoshi's wars in Korea, when Japanese military capacity equaled China's (Swope 2005, 2009); and just 0.1 in 1500 (as compared to 0.13 for the West). This would mean that Chinese war-making only rose to match the peak Roman levels around 1600, even though firearms had then been in use for three centuries.

War-making capacity rose sharply across the 17th century, and by 1696 Kangxi could take 235 heavy cannon (weighing 4-5 tons each) and 104 light cannon (weighing 40-400 kg) on his campaign against the Zunghar nomads (Perdue 2005: 184). But European war-making capacity had increased much faster. I estimate that European capacity roughly doubled between 1600 and 1700, from 0.18 to 0.35 points; I would suggest that Eastern capacity only increased by 25 percent, from 0.12 to 0.15 points (meaning that Kangxi's military power was midway between that of the Roman emperor Augustus [0.12 points] and that of the Habsburg emperor Philip II [0.18 points]).

Between 1750 and 1800 Chinese and Japanese military capacity both decayed sharply (Lorge 2005: 158-74). The Qing dynasty commanded about 850,000 soldiers in 1800, 250,000 of whom were supposedly elite Manchu Banner Men (Elleman 2001: 5); however, the quality, organization, and logistics of these forces had all collapsed since Kangxi's day. Emperor Qianlong took the honorific title "The Old Man of the Ten Complete Military Victories" in 1792, but in reality his forces suffered serious reverses in Burma, Vietnam, and Nepal.



Graph 54. Eastern and Western war-making capacity in the age of military revolution, 1500-1900 CE

By the time British observers saw Chinese armies and flotillas in action, in the 1840s, they were astonished by the backwardness of Eastern weapons and organization (Fay 1997; Elleman 2005: 3-34). In a famous comparison, the British officer Armine Mountain suggested that the Chinese forces looked like illustrations to Froissart's 14th-century chronicle of Anglo-French Hundred Years' War, "exactly as if the subjects of his old prints had assumed life and substance and colour, and were moving and acting before me unconscious of the march of the world through centuries, and of all modern usage, invention, or improvement" (cited from Fay 1997: 222). I estimated that Western war-making capacity increased from 0.10 points in 1300 CE to 0.11 in 1400; if that estimate is reliable, and if Armine's judgment was reliable too, that would mean that between 1700 and 1840 Eastern war making declined from 0.15 to about 0.11 points. I suspect that in fact Armine somewhat overstated the case, and that between 1700 and 1800, while European war-making capacity grew by almost 50 percent, from

0.35 to 0.5 points, Chinese capacity fell by 25 percent, from 0.15 points to just 0.12 points (and Japanese military effectiveness fell still lower).

This would mean that Qing armies in 1800 were no more effective than the Ming forces that had faced Hideyoshi shortly before 1600, but were at least somewhat more effective than the knights and archers who clashed at Crecy, Poitiers, and Agincourt. It would also mean that Eastern war-making capacity increased tenfold across the 19th century to produce the Japanese score in 1900 of 1.0 points (Graph 54).

[10.3.4] *Imperial China and the nomad anomaly, 200 BCE-1500 CE*

For much of China's 2,000-year imperial history its war-making capacity was greater than that of any rival in the East (or even the world), but there were exceptions. The most interesting relate to what in *Why the West Rules—For Now* (Morris 2010: 624) I called "the nomad anomaly."

On the whole, scores on the four traits I use to measure social development show considerable redundancy, but there are unusual social formations that buck that trend. Steppe nomads are the most important: these groups generally scored very poorly on organization and information technology and fairly poorly on energy capture, but before the age of gunpowder only the most efficient agrarian empires could get the better of them on the battlefield.

In the East that applied between 100 BCE and 100 CE, when Han armies regularly defeated the Xiongnu, and around the 7th century CE, when Tang armies achieved even greater dominance over the Turks. It was only after 1700, however, with drastic improvements in gunpowder weapons, that Qing armies really mastered the steppes (Perdue 2005). Before and between these periods of Chinese domination—around 200 BCE, 200-500 CE, and 800-1500 CE—steppe nomads could muster more military power than any agrarian state (Barfield 1989; di Cosmo 2002a, 2002b; di Cosmo et al. 2009).

Throughout this long period, the strongest steppe societies probably scored around 0.1 points (± 30-40 percent) for war making on the social development index. The lowest scores (perhaps around 0.06 or 0.07 points) were in the first two centuries CE, when the Roman, Parthian, and Han Empires successfully disrupted the creation of major pastoral empires anywhere on the steppes, and the highest (perhaps around 1.3 points, roughly twice as high as the Xiongnu) in the age of Genghis Khan. This would imply that Genghis Khan's Mongol hordes could have overrun the Roman Empire and would have been a match even for the Ottomans around 1500. There is of course no way to know if this is true, but

Tamerlane certainly considered his own Mongol hordes strong enough to overthrow the Ming in 1400, and another Mongol army did capture the Ming emperor on 1450 and could probably have sacked Beijing had it chosen to do so.

Famously, however, nomad rulers struggled when they tried to convert their war-making capacity into political power. Only those who came from "semi-nomad" backgrounds, such as the Xianbei in the 6th century CE, the Jurchens in the 12th, and the Manchus in the 17th, succeeded, establishing themselves as ruling dynasties (the Sui-Tang, Jin, and Qing respectively). Fully nomadic conquerors, such as the Mongols in the 13th-14th centuries CE, seem to have found it too difficult to make the cultural adjustments necessary for ruling an agrarian empire. Consequently, I have assigned scores for Chinese rather than nomadic war-making capacity throughout the period 200 BCE-1800 CE.

The broad shape of Eastern military history across this period is reasonably clear, although assigning precise scores is again a subjective matter. I will begin in the 15th century CE and work back to 200 BCE. In 1400, on the eve of Zheng He's voyages and Yongle's invasions of the steppes, Ming military power was enormous. On paper, the emperors commanded a coastal fleet of 3,500 ships (1,750 warships, 1,350 patrol boats, and 400 armed transports; Lo 1958a: 150) and an army of 1.2 million troops (Lorge 2005: 111). In reality, these forces were considerably smaller, but the biggest steppe invasion in 1414 did involve about 500,000 men (Lorge 2005: 116). Ming war-making capacity was certainly greater than of the contemporary Ottomans (to whom I assigned 0.11 points), but probably less than that of the Mongols at the height of their strength in the mid-13th century; I therefore estimate an Eastern score in 1400 of 0.12 points. By 1300, after their conquest of China, Mongol military power had probably declined somewhat from its peak in the mid-13th century, but remained formidable by premodern standards. The Mongol Yuan dynasty even revived China's fleets after they had fallen into disrepair in the mid-13th century (Lo 1955), reportedly sending 4,500 ships with 150,000 soldiers against Japan in 1274 (Rossabi 1988: 99-103). I suggest a score of 0.11 points, slightly lower than the early Ming dynasty peak, but this can only be a guess; estimates of 0.1 or 0.12 points are just as plausible.

The Song dynasty, despite its famously anti-military credentials, rapidly developed its armies in the late 10th century, reportedly commanding 650,000 men at Taizong's death in 997 and nearly 1 million at Zhengtong's death in 1022 (Mote 1999: 114; Lorge 2005: 48). Wang Anshi's reforms, brought on by the 11th-century fiscal crises, shifted the balance away from salaried professionals toward militias and reduced overall strengths, but the army remained strong. It mustered 320,000 troops and a similar number of porters in 1081 (Lorge 2005: 49), supported by enormous centralized armories, and even in the 1120s and 1130s the dynasty could still field forces of 100,000-200,000 (Mote 1999: 302; Lorge 2005: 51).

Southern Song rulers greatly strengthened their fleets for the 12th-century wars with the Jurchens, introducing much bigger ships, including paddleboats that could overcome winds and tides, and new weapons, such as flaming arrows, rockets, and flamethrowers. Twelfth-century paddleboats could be 60-90 m long, with 8 wheels and crews of 700-800. By the 1130s the biggest were more than 100 m long, and by 1200 some were armored with iron plates (Lo 1958b, 1969; Needham 1971; Rossabi 1988: 79).

Song military capacity between 1000 and 1200 was clearly much greater than anything in the fragmented West, where the Byzantine Empire had probably the strongest forces in 1000 and the Seljuk Turks in 1100 and 1200. I assigned 0.06 points to the Byzantines in 1000 and 0.07 and 0.08 to the Seljuks in 1100 and 1200. I tentatively suggest scoring Eastern capacity at 0.08 in 1000 and 0.09 in 1100-1200. That would mean that even at its height, Song war-making capacity did not equal imperial Rome's.

Under the Tang dynasty, however, war-making capacity came much closer Rome's. The sources for the early 8th century suggest that the Tang had about half a million men under arms (Twitchett 2000; D. Graff 2002: 210), in a highly centralized system with good discipline and long-service professional troops.

Tang military power rested on the fusion of steppe heavy cavalry with mass infantry developed by the states of Northern Wei and Northern Zhou and the successor Sui dynasty in the 6th century (D. Graff 2002: 97-159). This began with the Xianbei conquest of much of northern China in the early 5th century and accelerated with Emperor Xiaowen's reforms in the late 5th century, but even in the 530s 100,000 men still counted as a huge army (D. Graff 2002: 104). Only in the late 6th century did the consolidation of northern China's states generate vastly greater military power. In 589 the Sui emperor Wendi could muster 518,000 troops in the Yangzi valley for his conquest of southern China, supported by five-decker ships carrying up to 800 men and equipped with spiked booms for fixing and boarding enemy vessels (which sound strikingly like Rome's *corvus*-bearing quinqueremes developed in the late 260s BCE).

The Tang navy shrank steadily after the huge fleets built by the Sui for the unification of China in 589 and the disastrous wars against Koguryo in 612-14. That, however, was largely because there was no credible threat to the empire from the sea, and (at least until 755) China's internal peace required no major armed presence on its rivers. On the rare occasions that ships were needed, as when war broke out again with Korea in the 660s, the strong Tang state was able to build or requisition hundreds at short notice, and could mount large campaigns (D. Graff 2002: 199).

The civil wars that followed An Lushan's revolt in 755-63 hugely weakened the Tang Empire. In November 763 a Tibetan force was able to sack Chang'an, and for the next two centuries Chinese military energy was absorbed in recurring civil wars and partially successful efforts to fend off Tibetan raids. When central authority collapsed, provinces maintained their own armies, but not even the biggest (e.g., Pinglu) rose above 100,000 men. What troops there were tended to be poorly equipped, supplied, and led (D. Graff 2002: 227-51).

Before the early 5th-century Xianbei unification of northern China armies had been relatively large but were much less powerful than those of Tang times. In 279 CE, for instance, the state of Jin mustered 200,000 troops and supporting fleets to invade southern China down the Yangzi valley. The campaign was strikingly like the one in which Sui Wendi accomplished the same goal in the same region in 589, but the forces involved were only 40 percent of the size of Wendi's, and organizationally had more in common with the campaigns of the Han dynasty than with those of the Sui.

Across the next 200 years cavalry armies came to dominate China. Grave goods, figurines, and tomb reliefs provide plenty of information about weapons (Dien 2007: 331-39), showing that stirrups came into common use for cavalry in the 4th century. Combined with evidence from grave goods for increasing use of shock weapons and the spread of horse armor, this suggests that tactics went through major changes (Dien 1986).

While there were clearly significant developments in war-making capacity between 200 and 600 CE, it is not easy to assign scores to this "Period of Disunion." Eastern military forces never sank to anything like the level of weakness found in the West in the 7th-9th centuries, and state infrastructures survived. Even in the 4th century armies of 50,000-100,000 men remained common, and although siege trains virtually disappeared from northern Chinese armies, southern China's fortifications remained strong (Dien 2007: 15-45). Military capacity rose faster after 400 than before; working backward from the score of 0.09 points I assigned to the Sui forces in 600, I therefore propose scores of 0.08 points in 500 and 0.07 points for the whole period 200-400.

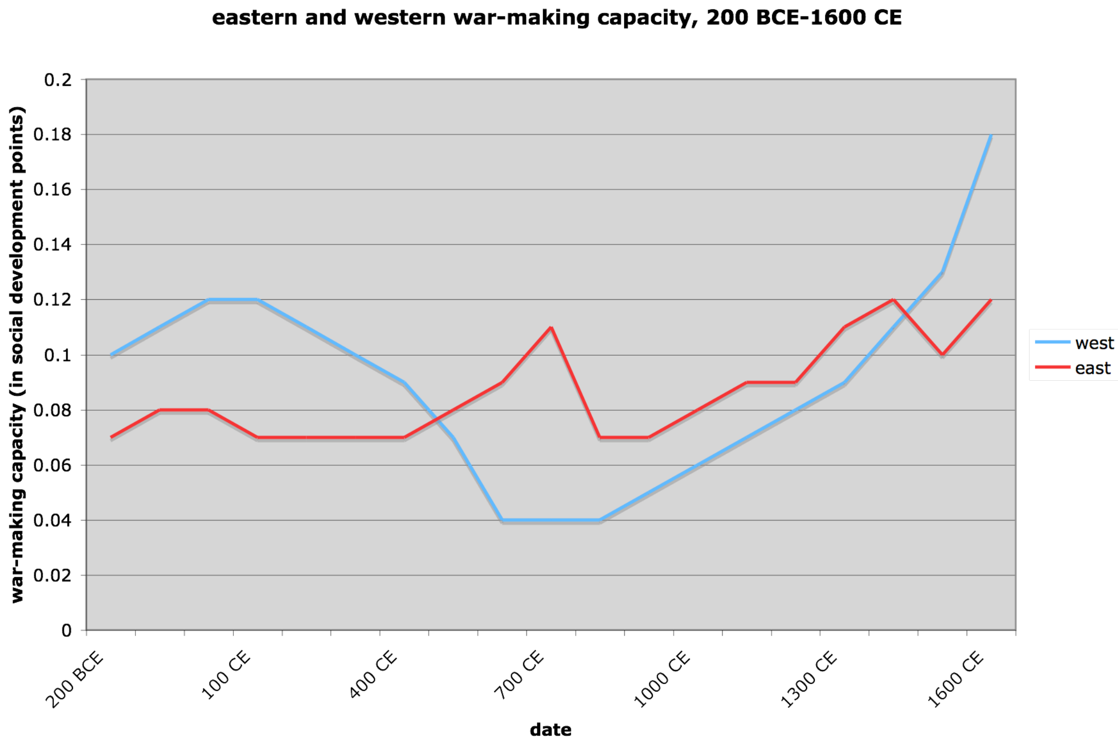
This flat score masks important changes, but unless we push the score for 600 higher, we are forced either to assume (as I do) that the changes between 200 and 400 were not large enough to register on the index, or to propose that the score fell below 0.07 points at some moment after 200 CE then climbed quickly. A score of 0.06 points would be equivalent to that for the West in the early 6th century CE or around 1000 CE, but my impression from the literature I have consulted (particularly D. Graff 2002; Lewis 2009a) is that Eastern war-making capacity remained above those levels throughout the Period of Disunion.

War-making capacity under the Western Han dynasty (206 BCE-9 CE) was higher still. The great wars of the 3rd century BCE had generated mass infantry armies that regularly ran into hundreds of thousands of troops on each side, using sophisticated siegecraft and logistics and even developing a body of profound military theory (Lewis 1990, 1999).

In 200 BCE navies were weak because control of the seas and rivers was rarely decisive; so too were cavalry forces, and many troops still used bronze rather than iron weapons. Over the next two centuries, however, iron arms steadily replaced bronze, and cavalry grew in importance as the main arena for conflict shifted from wars between Chinese armies to wars against Xiongnu nomads (Barfield 1989; di Cosmo 2002).

The size of Western Han armies fluctuated, declining after 200 BCE as emperors disarmed their client kings but spiking up again for great wars, such as the army of 140,000 infantry and 70,000 cavalry that Wudi sent against the Xiongnu in 97 BCE. Overall, though, the trend was downward, and in 31 CE the Eastern Han dynasty (ruled 25-220 CE) abolished universal military service and set about demilitarizing the core of the empire in earnest (Lewis 2000). By the 50s CE the Han Empire was shifting toward large garrison forces on the frontiers (often of allied cavalry under only the loosest imperial control) and a small standing army of about 40,000 men at the empire's core.

Han armies seem never to have reached the level of effectiveness of the Roman Empire's. I suggest scores of 0.08 points (as compared to a Roman peak of 0.12 points) in 100 BCE and 1 BCE/CE, then a slight decline to 0.07 points in 100 and 200 CE. As with most of the estimates in this section, there is a strong element of subjectivity, and Western Han scores could easily be raised to 0.1 points without straining the limits of the evidence too much. However, unless we assume that the Han military actually was a match for the Roman, there is no way to change the Eastern war-making score enough to have a serious impact on the social development index.



Graph 55. Eastern and Western war-making capacity, 200 BCE-1600 CE

The shape of the curves for Western and Eastern war-making capacity between 200 BCE and 1500 CE (Graph 55) suggest that it was probably impossible for any state to push their military effectiveness up above the 0.1-0.12 range before the gunpowder revolution took off. Despite all the difficulties of making sweeping comparisons across time and space (on which see Tilly 1984), imperial Roman, early Tang, and early Ming war-making techniques do seem to have reached roughly the same level; no amount of reorganizing could advance beyond this.

[10.3.5] *Early China, 1600-200 BCE*

As in analyses of early Western war making, the very small scores possible on the index produce a rather schematic effect (see Graph 52 on p. 156 above).

Archaeologists have found plenty of evidence for violence in Chinese prehistory, but only in the early 2nd millennium BCE do we see regular use of metal weapons and signs of military organization that we can reasonably think of as state-style warfare (Chang 1986; Liu and Chen 2010). Following the same principles that I applied to early Western war making, I therefore assign the first score of 0.01 points in 1600 BCE, which coincides roughly with the episodes conventionally associated with the arrival of the Shang. Eastern war-making was at roughly the same level in the mid 2nd millennium BCE as that in the Western core in the 3rd millennium BCE, waged with bronze-armed militias of just a few thousand men, no cavalry or chariots, no purpose-built warships, and fairly simple fortifications.

The time lag between Eastern and Western war-making capacity shrank sharply during the later 2nd millennium BCE. The spread of chariot warfare to both regions (reaching the West around 1800 BCE and the East around 1200 BCE) probably had a lot to do with this. Late Shang warfare seems to have been conducted on a much larger scale than that of Early Shang times (Keightley 1999). According to interpretations of the oracle bones, Shang expeditionary forces were normally around 3,000 strong, but on at least one occasion King Wuding and Lady Fushao assembled 10,000 men (Yates 1999: 13). By 1200 BCE these armies were using chariots, but they seem to have limited them primarily to transporting officers. I suggest that war-making capacity had risen sufficiently to lift the score to 0.02 points by 1200 BCE. I estimate that the Western score rose to 0.02 points in 1800 BCE, suggesting that the gap between Eastern and Western military power had narrowed to about 600 years.

In the West the pace of military change accelerated after 1500 BCE, as chariot corps became the central arm in the kingdoms around the east Mediterranean and increasingly professional forces developed under highly centralized leadership. I suggested that the score for war-making capacity increased to 0.03 points in 1400 BCE, then to 0.04 points in 1300. The East, it seems, went through a similar period of accelerating increases in military capacity in the late 2nd millennium BCE. By 1000 BCE the Zhou were using chariots *en masse*, much as Western armies had been doing since 1500 BCE (here I follow Shaughnessy 1988), and according to the *Shi ji* (admittedly, compiled almost a millennium later), in 1045 BCE King Wu of Zhou led 45,000 infantry, 6,000 allies, and 300 chariots in the war that overthrew the Shang (Shaughnessy 1999: 309; Yates 1999: 18). Even if the actual numbers were only half as large, this force would have been quite respectable by the standards of Western war making in 1500 BCE (although it would not have impressed the Western kings of the 13th century BCE). I therefore suggest a score of 0.03 points for Eastern war making in 1000 BCE.

Zhou armies seem to have grown during the 10th century BCE, and carried royal power far beyond the Wei and Yellow River valleys. After King Zhao's disastrous defeat on the Han River in 957 BCE, however, the state began to unravel. Assigning scores to such poorly known institutions is a rather arbitrary exercise, but I assume that Zhou capacity did not increase enough between 1000 and 900 BCE to raise the score above 0.03 points, but that the chaos into which the state descended after about 850 did lower the score back to 0.02 points.

Military capacity increased rapidly and steadily in the mid and late 1st millennium BCE. The most important changes were organizational, with a shift away from aristocrats raising levies and leading them in their own chariots to rulers taxing and conscripting free peasants in mass infantry armies. In the 7th century, 10,000 men was still considered a sizeable force. By the late 6th century, however, a major effort might raise 50,000 troops, and a century later, the greatest armies were twice as big (Lewis 1990: 60; 1999: 625). Historians began ranking states by the number of chariots they could field, with 1,000 chariots (probably 50 percent more than Duke Wen used in the great battle at Chengdu in 632 BCE) counting as small and 10,000 as large (Yates 1999: 20). Across the 4th and 3rd centuries, however, army sizes exploded. The numbers provided by our sources (which reach 600,000) are often suspect, but the state of Qin was certainly fielding hundreds of thousands of troops by 250 BCE (Lewis 1990: 60-61). Iron weapons did not become the norm till after 200 BCE (Wagner 1993), but the 4th and 3rd centuries BCE also saw chariots being replaced by cavalry and great advances in siege warfare (Needham and Yates 1994), including the straddling of much of northern China with long mudbrick walls designed to keep steppe raiders out.

In Graph 52 on p. 156 I represent the Eastern score for war making as increasing steadily between 700 and 100 BCE, from 0.02 to 0.08 points. This is certainly an oversimplification, and the rate of increase probably accelerated after 400 BCE, but given the tiny number of points involved this seemed less arbitrary than inserting plateaus and periods of faster change.

11 Information technology

[11.1] *Categorizing information technology*

Almost by definition, we are relatively well informed about the history of information technology, because every document that survives from the past is by its nature a piece of evidence for the state and spread of information technology. We can trace in some detail the rise of systems for storing and communicating information, the relative ease of accessing data, and the sophistication of the various technologies (e.g., Powell 2009). It is more difficult to measure the extent of use of different technologies, although European historians have made some valiant efforts to count how many people could read and write and at what levels of competence in the last 2,000 years (e.g., Stone 1964, 1969; Goody 1968; Harris 1989; Clanchy 1993). Numeracy has received less attention than literacy, despite its obvious importance, though again there have been some valuable studies (e.g., Bodde 1991, Crosby 1994, Netz 2002, Chrisomalis 2004, 2009, 2010), though scholars of numeracy have focused less than the scholars of literacy on the phenomenon's extent.

Since the 1980s there has been a reaction against quantification in studies of literacy, with many European historians concluding that since there are many kinds of literacy, trying to quantify reading and writing (numeracy has received less attention) is pointless (e.g., Street 1984, 1987; Chartier 1989). But while the first claim is undoubtedly true, the second does not follow from it; so long as we are explicit about what is meant by literacy and numeracy (on which I follow Heath 2003 and Chrisomalis 2009), and recognize that other historians, asking other questions, may prefer to define the terms in other ways, quantification is a necessary approach to many problems, and also provides a necessary baseline for almost all discussions.

To use information technology as a trait in the social development index we need to calculate separate scores for (a) the sophistication of the technologies available in East and West at specific points in time and (b) the extent of their use; and then we need to multiply the two numbers together to produce a series of scores for Eastern and Western information technology through history.

As in the case of war-making capacity, the greatest difficulty is not the scarcity of evidence for premodern times but the dramatic leap in technological sophistication during the 20th century, which makes it difficult to compare the information technology of 2000 CE with that of earlier periods. In *Why the West Rules—For Now* (Morris 2010: 636), I observed that Moore's Law, which states that the cost-effectiveness of information storage and retrieval has been doubling every 18 months since 1950, would seem to imply that the Western score in 2000 CE should be well over a billion times higher than that for 1950 CE. The Western score of 250 points in 2000 CE would in fact fall to the lowest measurable score, of 0.01 points, before we even get back to 1970.

Many of us remember the reel-to-reel tape machines and mainframe computers of the 1970s, machines that seem positively archaic next to the iPods and iPads of our own enlightened times; yet it is ridiculous to suggest that information technology in the era of the first moon landing was too primitive to be measurable. Calculating information technology scores requires weighting different kinds of system and recognizing that shifts between them are not linear or straightforward. Writing has not replaced speech; nor has the telephone or text messaging replaced face-to-face communication. New forms of information technology may eventually completely replace those that evolved over the last few hundred thousand years, but this has not happened yet, and in calculating historical scores for information technology we will have to recognize the complicated, overlapping patterns.

The evidence for how many people could read, write, and count, at what levels of skill, and using what technologies is fragmentary and open to competing interpretations; and the need to make allowance for the partialness of changes through time adds a further level of subjectivity to the calculations. Scores for information technology are therefore even more open to debate than those for the other three traits.

[11.2] *Calculating information technology scores*

The difficulties of categorizing information technology call for a two-stage approach to scoring.

1. Skills. Following common practice among historians, I divide the population into a three-part typology (full, medium, and basic), according to people's skills in using the information technology available in their age. Again following standard practice, I define each category in a way that sets the bar low. Literacy and numeracy have been the most important technologies for storing and communicating complex information in East and West alike for most of the last few thousand years. "Basic" skills involve being able to read and write a name or perform very simple calculations; "medium" means being able to read or write a simple sentence or solve more complicated problems in addition, subtraction, multiplication, and division;

and "full," being able to read or write more connected prose or use more advanced mathematical techniques.

Some anthropologists and historians have suggested that definitions of this kind are Eurocentric, and that there are cultural traditions in which language and mathematics work in entirely different ways (e.g., D. Everett 2005), but these claims seem to have little empirical support (e.g., on numeracy, Crump 1990, Frank et al. 2008; on spoken language, the debate between Nevins et al. 2009a, 2009b, and D. Everett 2009). The division into basic/medium/full literacy, for instance, was independently developed by the Chinese Communist Party in its 1950 literacy drive (full literacy = being able to recognize 1,000+ characters; semiliteracy = recognizing 500-1,000 characters; basic literacy = 300-500 characters) (Bastid 1988; P. Bailey 1990; Seeberg 1990).

Drawing on the available scholarship (using experts' quantitative estimates on the rare occasions they are available, and extrapolating from the qualitative discussions the rest of the time), I divide the adult male population at different periods across these three categories of full, medium, and basic. I assign 0.5 information technology (IT) points for each 1 percent of the adult male population that falls into the full-skills category; 0.25 IT points for each 1 percent of the adult male population that falls into the medium-skills category; and 0.15 IT points for each 1 percent of the adult male population that falls into the basic-skills category. These numbers are, and can only be, arbitrary estimates of the difference between each level of mastery of information technology. They may be quite reasonable for some times and places but are surely very wide of the mark in others. However, consistency in scoring seems more important than spurious and highly subjective attempts at greater accuracy. Adding together the scores yields a single "Male IT" result for each period. If the numbers I have suggested for the high, medium, and low skill categories seem unreasonable, critics can of course experiment with other numbers and find out how much they need to be changed in order to make a serious difference to the social development index.

The evidence for female literacy and numeracy is generally even poorer than that for male literacy and numeracy, though we can be sure that in most or all times and places before the 20th century, fewer (usually far fewer) women could read, write, and perform mathematical calculations than men, and usually at lower levels. There are simply no reliable statistics for male/female differences in premodern times, which means that I am once again reduced to guesswork, constrained only by general impressions drawn from the historical sources. However, making explicit guesses should be more constructive than leaving assumptions implicit, so I hazard a series of estimates for others to challenge if they see fit. I then apply the estimated gender multiplier for each period to the Male IT score to produce a Female IT score; adding the two scores together yields a single score in IT points for East or West at a specific point in time. In the Western core in 2000 CE, I place 100 percent of males in the full skills category as defined here, generating a Male IT score of 50 (i.e., 100 percent x 0.5), and female skills score 100 percent of the male rate, generating a Female IT score of 50 (i.e., the male 50 points x 100 percent). (The United Nations Human Development Report [http://hdr.undp.org/en/] for 2009 actually uses 99 percent (United Nations Human Development Programme 2009: 171, Table H), but for ease of calculation I have simplified and used 100 percent.) The West's score in IT points for 2000 CE is therefore 100.

Professional literacy and numeracy providers in the Western core conventionally set much higher standards for basic, medium, or full skills than historians use, and would consequently disagree not only with my assertion that 100 percent of males have full skills but also with the claim that female numeracy skills match male (Kathryn St. John, personal communication). However, while setting the bars for basic, medium, and full literacy and numeracy at very high levels is completely appropriate for those seeking to raise standards within complex 21st-century societies, it would be unhelpful for long-term cross-cultural comparisons, because it would reduce all pre-1900 scores to zero.

2. Speed and reach of technologies. The second stage in calculating scores is to establish another multiplier to reflect the changing speed and reach of technologies for storing and communicating information. I divide tools for handling information into three broad categories: electronic (in widespread use in East and West alike in 2000 CE), electrical (in widespread use in the West but not in the East in 1900 CE), and pre-electrical (in use in the West for perhaps 11,000 years and in the East for perhaps 9,000 years).

I assign multiplier values of 2.5 for the most advanced forms of electronic media, in use in the West in 2000 CE. In the East in 2000 CE similar media were in use, but were less widely available. Telephones (both land-line and mobile) and televisions were roughly equally common in West and East (*Economist* 2004: 88), but computers and Internet hosts were more common in the West (62.3 computers per 100 people in the USA as compared to 38.5 computers/100 people in Hong Kong and 34.9 computers/100 people in Japan [*Economist* 2004: 89]; 375.1 Internet hosts/100 people in the USA as compared to 97.3 Internet hosts/100 people in Taiwan and 72.7 Internet hosts/100 people in Japan [*Economist* 2004: 91]). Since the Western multiplier in 2000 CE is set at 2.5, I use a multiplier of 1.89, for the Eastern core. The West's score for information technology on the social development index in 2000 CE is 250 points (i.e., 100 IT points x 2.5); the East's is 189 (i.e., 100 IT points x 1.89).

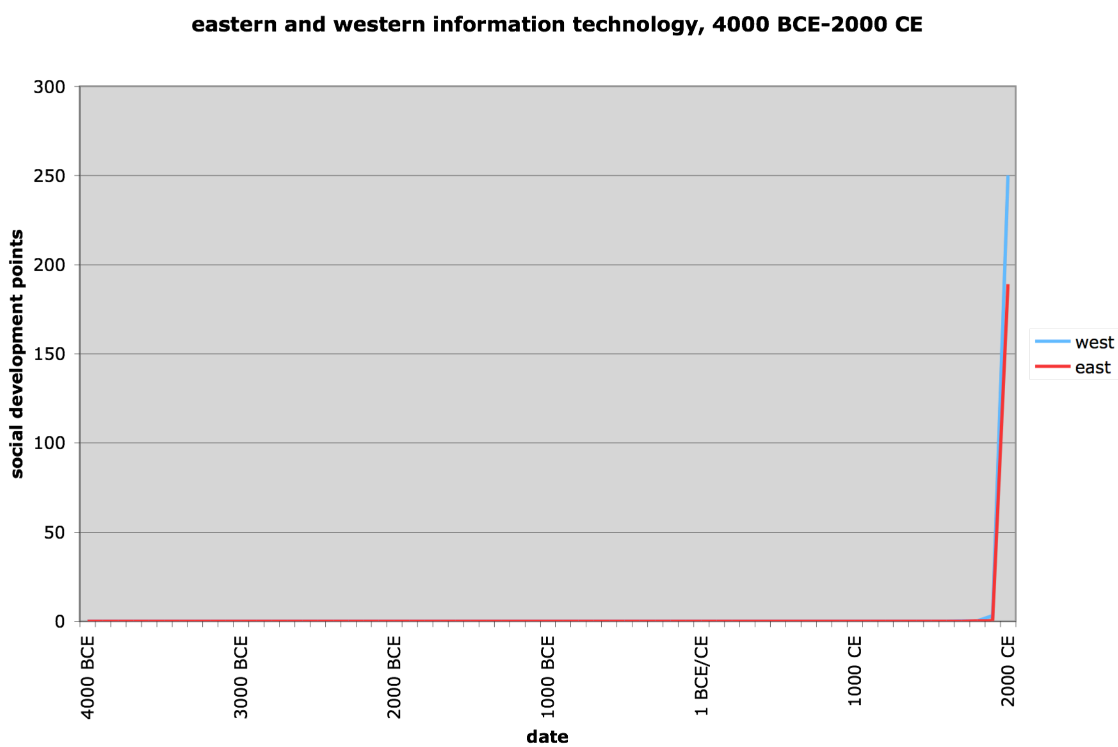
The electronic multiplier of 2.5 for the Western core in 2000 CE is fixed by the fact that the maximum score possible for a trait is 250 points, but the values for electrical and pre-electrical media are much harder to calculate. I am not aware of previous attempts to calculate the overall increase in the capacity of information technology across the 20th century, but drawing on the expert literature (particularly Balk 2005; Barnouw 1990; Briggs and Burke 2002; Fischer 1994; Norman 2005; Starr 2005), my sense is that the electronic media available in 2000 CE represented something like a 50-fold increase in capacity over the electrical media available in the West in 1900 CE. This would mean that the multiplier for the Western core in 1900 was 0.05.

The 19th century also saw extraordinary improvements in information technology (Briggs and Burke 2002; Kern 2003; Norman 2005; Standage 2007), though they were clearly not on such a scale as those of the 20th century. I suggest that the electrical media available in the West in 1900 CE in turn represented something like a 5-fold increase in capacity over the pre-electrical media available in 1800 CE, leading to a multiplier of 0.01 for 1800, which I treat as a base level for all pre-electrical information technology systems going back to the first documented experiments with visual notations, around 9000 BCE in the West and 6250 BCE in the East.

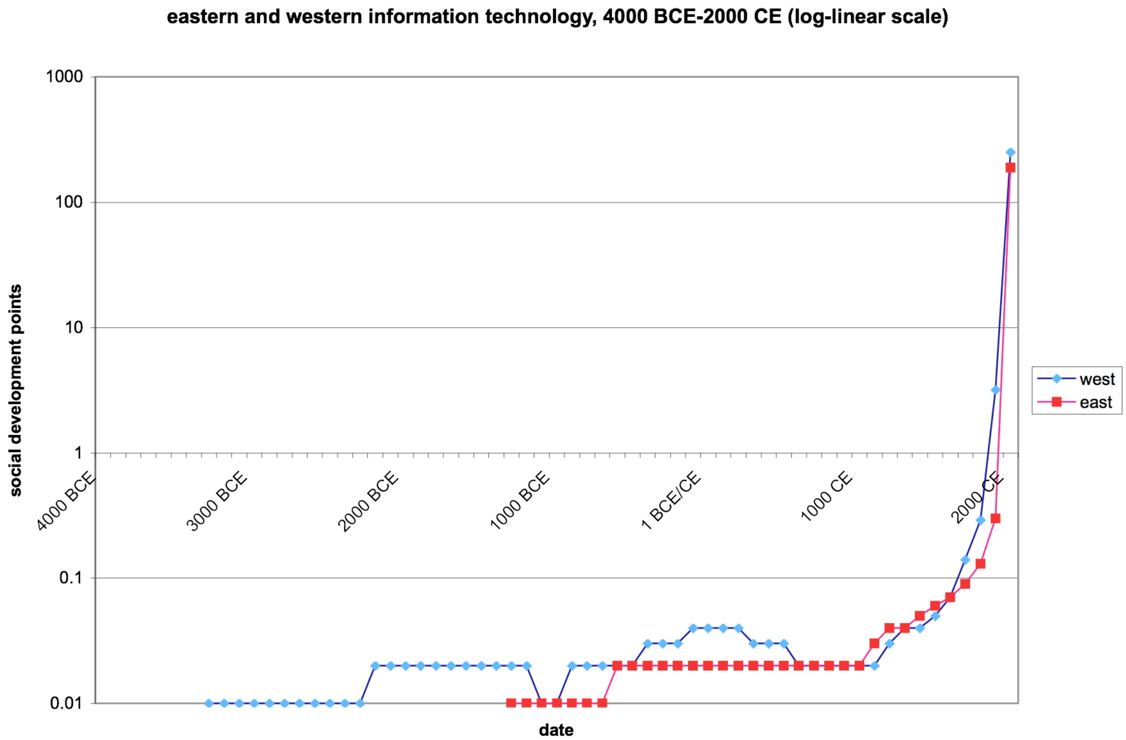
Others may disagree with the numbers I propose, and of course there were variations within the crude category of pre-electrical information technology. Historians may particularly notice that I have not made a categorical distinction between print and pre-print media, even though the impact of printing presses on European elite culture in the 15th century and Eastern elite culture since the 7th century is well known (e.g., Eisenstein 1979; T. H. Barrett 2008; Brokaw and Chow 2005; Chow 2004; McDermott 2006; McKitterick 1998). I made this decision because the main contribution of printing was to generate more and cheaper materials, rather than to transform information storage and retrieval the way that the telegraph and the Internet would do in the 19th and 20th centuries, and these purely quantitative changes are already factored into the index. However, even if other scholars disagree with this assumption, the numbers involved in information technology scores before 1900 CE are so tiny that—even more than in the case of war-making capacity—it would take enormous revisions of these multipliers to have much impact on the final social development scores.

For similar reasons, I have not distinguished between forms of notation, treating alphabetic, syllabic, ideographic, and other styles of writing simply as variants on pre-electrical systems. This oversimplifies reality (cf. Powell 2009), but because (a) judgments on the relative efficiency of writing systems descend too easily into culture-bound value judgments and (b) the tiny scores at all points before 1700 CE mean that no plausible adjustment would have a serious impact, I decided simply to treat all versions of pre-electrical information technology systems as identical and to concentrate on measuring the extent of their use.

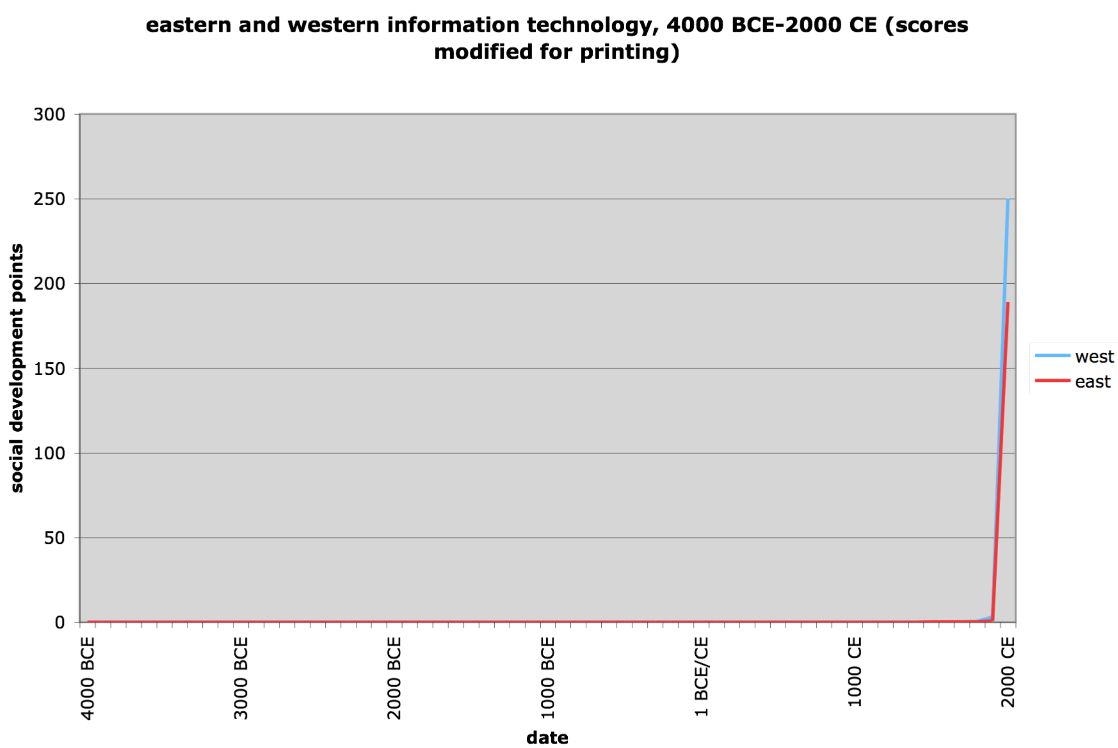
Finally, I have not made a separate category for pre-electrical calculating devices like the abacus, first attested in Mesopotamia around 2500 BCE, or the Inca quipu, which, in a simple form, may be roughly equally old (Ifrah 2001; Benyon-Davies 2007). This is for the same reason that I did not make a distinction with the printing press; pre-electrical calculators speeded up counting and improved its accuracy, but did not transform the process as computers have done.



Graph 56. Eastern and Western information technology, 4000 BCE-2000 CE

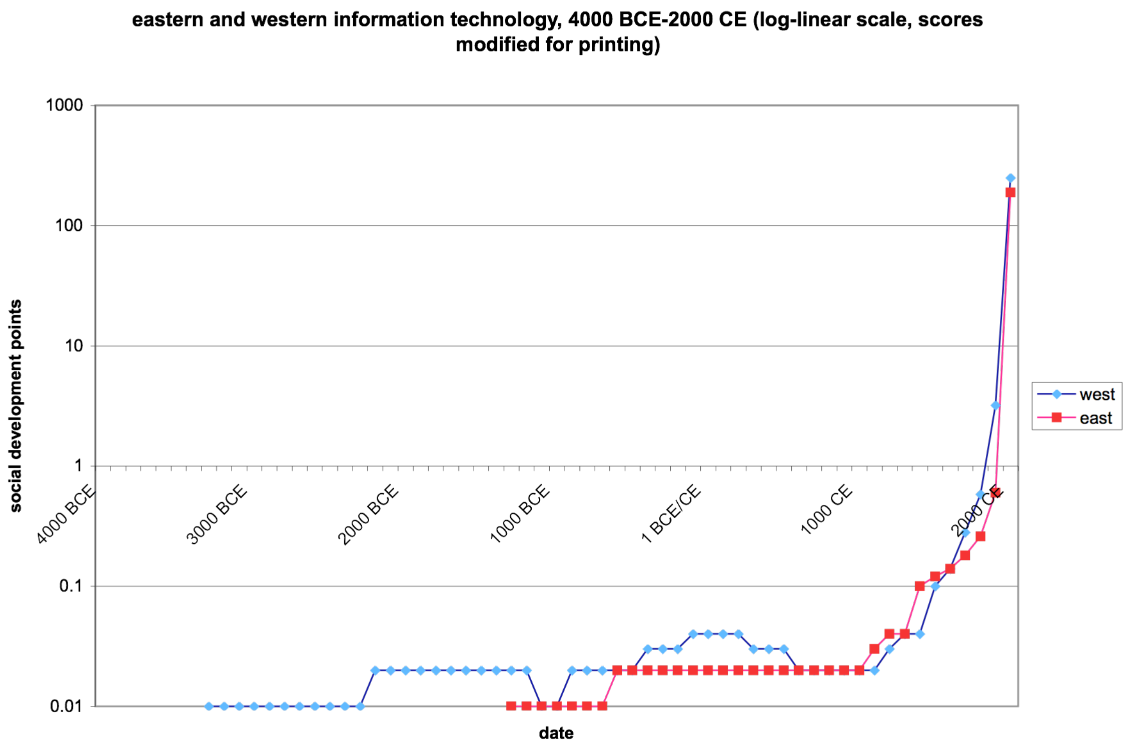


Graph 57. Eastern and Western information technology, 4000 BCE-2000 CE, shown on a log-linear scale



Graph 58. Eastern and Western information technology, 4000 BCE-2000 CE; scores doubled for printing in the East for 1400-1900 CE and in the West for 1500-1800 CE

Graph 56 shows the scores I have calculated, on a linear-linear scale: the Western score in 1900 CE is just about visible, but no earlier scores can be seen at this scale. Graph 57 shows the same data on a log-linear scale. Changing the Western multiplier for 1500-1800 CE to 0.02 to reflect a greater impact from the printing press and changing the Eastern multiplier for 1400-1900 CE to 0.02 to reflect the great expansion of printing in that period makes no visible change to a linear-linear representation (Graph 58) and very little change on a log-linear scale (Graph 59).



Graph 59. Eastern and Western information technology, 4000 BCE-2000 CE, on a log-linear scale; scores doubled for printing in the East for 1400-1900 CE and in the West for 1500-1800 CE

This method of calculation rests on one further key assumption: that the adoption of visible symbols for recording concepts is crucially important. Humans were talking and counting for tens of thousands of years before they started writing or using numerical notations, and they preserved and communicated enormous amounts of information in their traditions, rituals, and art. By definition, however, all purely oral systems of information technology automatically score zero in my system.

I have three reasons for proceeding in this way.

First, a biological consideration: human brains are the same everywhere, and despite the claims mentioned in section 1 above for extreme variations between cultures, no convincing evidence has yet appeared for major differences in the abilities of people in different oral cultures to process and store information in their heads or to communicate it orally. If this is correct, for comparative purposes preliterate information technology systems effectively zero each other out: only with the development of more sophisticated techniques of literacy and numeracy do measurable differences start to emerge.

Second, a practical consideration: even if the assumption described in the previous paragraph is in fact false, I know of no way to measure and compare the information technology systems of different non-literate cultures in the past. If Eastern oral cultures processed, stored, and/or communicated information better than Western oral cultures in the era before the first evidence for systems of notation in either region (around 9300 BCE in the West and 7000 BCE in the East), or vice versa, there is no way that we will ever know about it.

Third, an empirical consideration: the revolutionary consequences of using visible symbols to record verbal and mathematical concepts are well established (e.g., Goody and Watt 1963; Goody 1968, 1977a, 1977b, 1987; Ong 1982). Numerous critics, who often label those who stress the efficiency of visual recording "evolutionists," have pointed out plenty of reasons to exercise caution about extreme claims, and to be flexible (e.g., Pattison 1982; Graff 1987; Finnegan 1988; Halverson 1992). But after nearly half a century of arguments, it still seems clear that whether the shift from purely oral to various combinations of oral and written information technology empowered the individual, created hierarchy, or did both at once, it also marked a major step in increasing human abilities to store, access, and transmit information. In the West, where the evidence has received particularly detailed study, the earliest notations were probably for accounting, with verbal forms emerging gradually from them (Schmandt-Besserat 1992). In the East the evidence is less clear (Demattè 2010), but the same pattern may apply there too.

I present the full scores in Tables 9 and 10 and in Graphs 56 and 57 on pp. 177-78 above.

Table 9. Western information technology scores

	Categories (percentages)							
Dates	Full (@0.5 pts)	Medium (@0.25 pts)	Basic (@0.15 pts)	Male points	Female (%M)	Literacy points	Multiplier	Total points
2000 CE	100 (50)	0	0	50	100% = 50	100	x 2.5	250
1900	40 (20)	50 (12.5)	7 (1.05)	33.6	90% = 30.2	63.8	x 0.05	3.19
1800	20 (10)	25 (6.25)	20 (3)	19.3	50% = 9.65	28.95	x 0.01	0.29
1700	10 (5)	15 (3.75)	25 (3.75)	12.5	10% = 1.25	13.75	x 0.01	0.14
1600	5 (2.5)	10 (2.5)	10 (1.5)	6.5	2% = 0.13	6.63	x 0.01	0.07
1500	4 (2)	8 (2)	6 (0.9)	4.9	2% = 0.10	5.0	x 0.01	0.05
1400	3 (1.5)	6 (1.5)	4 (0.6)	3.6	1% = 0.04	3.64	x 0.01	0.04
1300	3 (1.5)	6 (1.5)	4 (0.6)	3.6	1% = 0.04	3.64	x 0.01	0.04
1200	3 (1.5)	6 (1.5)	4 (0.6)	3.6	1% = 0.04	3.64	x 0.01	0.04
1100	2 (1)	4 (1)	2 (0.3)	2.3	1% = 0.02	2.32	x 0.01	0.02
1000	2 (1)	4 (1)	2 (0.3)	2.3	1% = 0.02	2.32	x 0.01	0.02
600-900	2 (1)	2 (0.5)	1 (0.15)	1.65	1% = 0.02	1.67	x 0.01	0.02
300-500 CE	3 (1.5)	4 (1)	3 (0.45)	2.95	1% = 0.03	2.98	x 0.01	0.03
100 BCE–200 CE	4 (2)	6 (1.5)	5 (0.75)	4.25	1% = 0.04	4.29	x 0.01	0.04
500-200 BCE	2 (1)	3 (0.75)	2 (0.3)	2.05	1% = 0.02	2.07	x 0.01	0.02
900-600 BCE	1 (1)	2 (0.5)	1 (0.15)	1.65	1% = 0.02	1.67	x 0.01	0.02
1100, 1000 BCE	1 (1)	1 (0.25)	1 (0.15)	1.4	1% = 0.01	1.41	x 0.01	0.01
2200-1200 BCE	1 (1)	2 (0.5)	1 (0.15)	1.65	1% = 0.02	1.67	x 0.01	0.02
2700-2300 BCE	1 (1)	1 (0.25)	1 (0.15)	1.4	1% = 0.01	1.41	x 0.01	0.01
3300-2800 BCE	0 (1)	1 (0.25)	2 (0.3)	0.55	1% = 0.01	0.56	x 0.01	0.01
6000-3400 BCE	0	0	1 (0.15)	0.15	1% = 0	0.15	x 0.01	0
9000-6100 BCE	0	0	0	0	0	0	x 0.01	0
9300-9000 BCE	0	0	1 (0.15)	0.15	1% = 0	0.15	x 0.01	0

Table 10. Eastern information technology scores

Dates	Categories (percentages) Full (@0.5 pts)	Medium (@0.25 pts)	Basic (@0.15 pts)	Male points	Female (%M)	Literacy points	Multiplier	Total points
2000	100 (50)	0	0	50	100% = 50	100	x 1.89	189.00
1900	15 (7.5)	60 (15)	10 (1.5)	24	25% = 6	30	x 0.01	0.30
1800	5 (2.5)	35 (8.75)	10 (1.5)	12.75	5% = 0.64	13.39	x 0.01	0.13
1700	5 (2.5)	20 (5)	10 (1.5)	9	2% = 0.18	9.18	x 0.01	0.09
1600	4 (2)	15 (3.75)	10 (1.5)	7.25	2% = 0.15	7.4	x 0.01	0.07
1500	3 (1.5)	10 (2.5)	10 (1.5)	5.5	2% = 0.11	5.61	x 0.01	0.06
1400	3 (1.5)	10 (2.5)	10 (1.5)	5.5	2% = 0.11	5.61	x 0.01	0.06
1300	3 (1.5)	5 (1.25)	5 (0.75)	3.5	1% = 0.04	3.54	x 0.01	0.04
1200	3 (1.5)	5 (1.25)	5 (0.75)	3.5	1% = 0.04	3.54	x 0.01	0.04
1100	2 (1)	2 (0.5)	3 (0.45)	1.95	1% = 0.02	1.97	x 0.01	0.02
600 BCE–1000 CE	2 (1)	2 (0.5)	2 (0.3)	1.8	1% = 0.02	1.82	x 0.01	0.02
1000–700 BCE	2 (1)	1 (0.25)	1 (0.15)	1.4	1% = 0.01	1.41	x 0.01	0.01
1300–1100 BCE	1 (0.5)	1 (0.25)	1 (0.15)	0.9	1% = 0.01	0.91	x 0.01	0.01
7000-1400 BCE	0	0	1 (0.15)	0.15	1% = 0	0.15	x 0.01	0

[11.3] *Estimates of Western information technology*

The nature of the evidence changes significantly as we move back through time, but a very rough picture can nevertheless be put together. Between the mid 1960s and mid 1980s, historians did pioneering work on European literacy rates between 1600 and 1900 CE (e.g., Cipolla 1969; Cressy 1980; Furet and Ozouf 1982; Houston 1983, 1988; Maynes 1984; Sanderson 1972; Schofield 1968, 1973; Stephens 1976; Stone 1964, 1969), discussing different levels of male and female literacy across time. A small amount of work of this kind was also done on the USA (Lockridge 1974; Soltow and Stevens 1981).

Since the mid-1980s this kind of quantitative approach has been criticized (e.g., K. Thomas 1986), and historians have steadily abandoned quantification in favor of the cultural histories of the book and communities of readers (Kaestle 1985 provides a good overview). The methodological problems involved in reconstructing early-modern literacy rates are certainly severe (e.g., Cressy 1980; Gilmore 1982; Hamerow 1983; Lockridge 1974; Schofield 1968), but the shift in research seems to be driven more by the broader historiographical trend away from quantification than by serious evidence that the results of the 1960s-80s were flawed.

The general picture that emerges from the specialist studies is one of enormous local variation in literacy rates (Stephens 1977) combined with a broad trend across Europe and North America from 1600 CE onward toward increasing literacy at all levels plus a declining gap between male and female literacy. On my index, the numbers proposed by Cipolla, Stone, and others translate to scores roughly doubling each century between 1600 and 1800 CE, rising (in social development points) rising from 0.07 to 0.29 points, then shooting up to 3.19 points in 1900.

Before 1600 the evidence is less good. Medievalists have studied the European sources for literacy intensively (e.g., Arlinghaus et al. 2006; Britnell 1997; Clanchy 1983; Petrucci 1992; Pryce 2006; Schofield 1968), but numeracy has been relatively neglected (for exceptions, see Crosby 1994; Landes 1983). In the Muslim core, the opposite situation applies; very little has been written on literacy (e.g., Atiyeh 2005, although the essays focus mostly on the modern period), but science and mathematics have received more attention (e.g., Dallal 2010; Hill 1994; Iqbal 2009; Masood 2009; Saliba 2007; Turner 1997; and the enormous bibliography in Abattouy 2007). There have been fewer studies focusing specifically on medieval Islamic education in levels of popular literacy and numeracy (Berkey 1992 and Makdisi 1981 are partial exceptions).

There seems to be some agreement that male literacy and numeracy were rising slowly in Western Europe from the time of what historians sometimes call the "12th-century renaissance" (Haskins 1971; Swanson 1999), and that levels were very low indeed before 1100. Numbers of literate and numerate women probably only began rising steadily after 1500. Scholars of Islamic education are rarely willing to hazard any quantitative estimates at all, but it would seem that while the top Muslim scholars were more numerate and at least as literate as those in Christendom before 1100, literacy was restricted to very narrow circles. We might characterize medieval Islamic literacy as a scribal and priestly phenomenon, while literacy in Christian Europe was becoming characteristic of a broader craftsman stratum (even if the writing being read was often biblical). The Muslim world saw nothing like Europe's 16th-century boom in male reading of holy texts or its expansion of female literacy.

Probably fewer than 10 percent of Western men could read in 1100, and an even smaller number (perhaps 2 percent?) could be said to be fully literate. The numbers for women are particularly elusive, but seem to have been so tiny—perhaps 1 literature woman for every 100 literate men—that they make almost no difference to the scores. I estimate a social development score of just 0.02 points for the West around 1100, rising by slow increments to 0.05 in 1500, and then increasing more rapidly.

Literacy and numeracy seem to have been wider and deeper phenomena in classical antiquity than in the Middle Ages (Beard et al. 1991; Bowman and Woolf 1997; Harris 1989; Netz 2002), particularly in democratic Athens (508-322 BCE) and Italy between about 200 BCE and 200 CE. William Harris (1989) has provided particularly solid quantitative estimates, which I generally follow. Much recent scholarship on ancient literacy, like that among medievalists and anthropologists, emphasizes that literacy was a more complicated phenomenon than a single score suggests (e.g., R. Thomas 1992; Johnson and Parker 2009), but Harris' work already took the variety of forms of literacy into account in calculating rates. Other recent work has suggested that as well as oversimplifying the complexity of literacy, Harris' figures also understates the levels of popular accomplishment in information technology in classical Athens (Missiou 2010; cf. Ober 2008 on Athenian learning and innovation) and the early Roman Empire (cf. Bowman 1998, presenting evidence for surprising levels of literacy among ordinary soldiers on the Roman frontier). I estimate that the social development score for information technology in the Western core peaked around 0.04 points between 100 BCE and 200 CE. After 200 CE it declined (see, e.g., N. Everett 2010); I estimate scores of 0.03 points for 300-500 CE, then, for lack of any clearer evidence, a fairly static level of 0.02 until the revival after 1100 CE.

Looking back before 100 BCE, I suggest that between 400 and 200 BCE information technology scored 0.03 points in the core areas around the shores of the Aegean and East Mediterranean, rising from 0.02 points in the earlier 1st millennium BCE. With such tiny scores, precision and nuance both become impossible; I treat information technology as basically flat between 2200 BCE (the rise of the bureaucratic states of Akkad and Ur III) and 500 BCE (the beginning of the spread of democratic states in Greece), representing a combination of what historians often call "scribal literacy" and "craft literacy" (and, I would add, numeracy). By scribal/craft literacy I mean that a tiny educated elite (perhaps 1 percent of the male population) had full mastery of a literary canon, a slightly larger (perhaps 2 percent of the male population) bureaucratic elite had mastery of recording techniques, and another small (1-2 percent?) group of artisans could read or write their own names and perform the calculations they needed in their professions. This scribal/craft information technology scores 0.02 social development points, apart from an interruption during the period of collapse between 1200 and 1000 BCE, when evidence for writing of all kinds contracts sharply. In Greece writing probably went out of use altogether, and around the East Mediterranean as a whole very few documents survive. During this "dark age" I assign scores of 0.01 points.

The first convincing evidence of scribal numeracy and literacy appears around 3300 BCE in southern Mesopotamia (Schmandt-Besserat 1992), and I begin assigning scores of 0.01 points at that date. Information technology increased in sophistication and extent of use across the next thousand years, but given that 0.01 points is the smallest increment available on the social development index, Graph 57 on p. 178 above represents the curve as flat until it jumps in 2200 BCE. There are hints of symbolic activity that we might choose to call writing or mathematics going back as far as 9000 BCE (Akkermans and Schwartz 2003: 88), but these traces are so scarce that I treat them as scoring zero.

[11.4] *Estimates of Eastern information technology*

There has been much less quantitative analysis of Eastern literacy and numeracy in the languages accessible to me than of Western levels, and this is reflected in the flat scores in Graph 57 on p. 178 above and the brevity of Table 10 on p. 182 above. The scores I assign to the East probably oversimplify a more complicated pattern, full of ebbs and flows like those represented in the Western scores.

In 2000 CE, I follow the UN HDI (United Nations Human Development Programme 2009) (http://hdr.undp.org/en/) in treating

Eastern literacy rates in the Japanese core as roughly similar to those in the Western core, but use a lower multiplier than the West's 2.5 to reflect the narrower availability of electronic media in Japan than in the United States in 2000. The *Economist Pocket World in Figures* suggests that telephones (both land-line and mobile) and televisions were roughly equally common in West and East (*Economist* 2004: 88), but computers and Internet hosts were more common in the West (62.3 computers per 100 people in the USA as compared to 38.5 computers/100 people in Hong Kong and 34.9 computers/100 people in Japan [*Economist* 2004: 89]; 375.1 Internet hosts/100 people in the USA as compared to 97.3 Internet hosts/100 people in Taiwan and 72.7 Internet hosts/100 people in Japan [*Economist* 2004: 91]). I therefore use an Eastern multiplier of 1.89, producing an Eastern score of 189 social development points (i.e., 100 IT points x 1.89).

In 1900, strenuous efforts by the Japanese government had begun spreading mass literacy. While standards were low compared to the Western core, they were far higher than in premodern cultures, and perhaps 85 percent of boys and 25 percent of girls had at least some skills (I base these estimates largely on Duke 2009). There is room for some debate over the levels attained, but because Japanese information technology remained largely pre-electrical even in 1900, the East; West gap in social development points was at this stage enormous. I calculate that the Eastern score (30 IT points x a multiplier of just 0.01, reflecting the pre-electrical stage) was just 0.3 points, as compared to 3.19 points in the West. Chinese literacy and numeracy levels were even lower than Japanese around 1900, thanks to the educated elite's ambiguity about mass education (P. Bailey 1990; Bastid 1988). Chinese levels were very high by premodern standards, and probably at least 50 percent of boys reached the basic standard, but steps toward mass education remained hesitant. Only after the communist takeover in 1949 did mass education really take off (Seeberg 1990).

Before the late 19th-century Japanese takeoff, the Eastern core in China had a very high level of premodern craft literacy and numeracy. The Qing era saw a steady expansion of basic education and craft literacy. Around 1700 perhaps just 5 percent of men could be said to read reasonably fluently and 35 percent of boys learned a few characters, but by 1800 as many as half of the boys in northern China were learning a few characters (I extrapolate these numbers from Rawski 1978; Ridley 1973; T. Lee 2000). Female literacy and numeracy were much more restricted. Western literacy and numeracy rates were higher in the 18th and 19th centuries (particularly for women), but the numbers were still small enough that the actual differences in social development points (by my calculations, 0.14 for the

West in 1700, doubling to 0.29 in 1800, as compared to 0.09 for the East in 1700, rising by about half to 0.13 in 1800) were relatively small.

In Ming dynasty times the scores seem to have been lower, although they were probably higher than in the West before it began its information boom after 1600. There may not have been great differences between elites of education at each end of Eurasia, but China seems to have had a significantly bigger group of people (overwhelmingly men) with medium literacy and numeracy levels (e.g., Jami 1994; Brook 1998: 56-65). Actual numbers are necessarily impressionistic (I calculate 0.06 points in 1500 and 0.07 in 1600, as against 0.05 and 0.07 in the West), but because the scores are so low before the 17th century, the margin of error would need to be very large to have a serious impact on the social development index. Levels in Japan were probably quite close to those in China (cf. Rubinger 2007).

Moving back into earlier periods of course involves even more imprecision. Elite education improved drastically in Tang and Song times (e.g., T. Lee 1985; Bodde 1991; T. H. Barrett 2008; Kuhn 2009: 120-37), and the boom in books and financial recordkeeping in the 10th-12th centuries (Elvin 1973: 181-95) suggests to me that the use of information technology was roughly comparable with that in the West under the Roman Empire (i.e., a score of 0.04 points). Scores of 0.03 or 0.05 are equally plausible, but a score as low as 0.02 (comparable to that I assigned to the West between 600 and 900 CE) or as high as 0.06 (comparable to the 16th-century West) seems unlikely. I suggest that scores rose rapidly from about 0.02 points in 1000 CE to 0.06 in 1400.

In the absence of any good reason to do otherwise, I have simply hypothesized a flat score of 0.02 points for the long period between 600 BCE and 1000 CE. Literacy and numeracy rates certainly fluctuated across these sixteen centuries, rising between 600 BCE and 100 CE, falling between 100 and 400 CE, and rising again after 400 CE (in general terms, see Lewis 1999b, 2007, 2009a). The contrast between the epigraphic evidence from the Han and Roman Empires, however, is strong, and although precise numbers are necessarily speculative, it is clear that Chinese literacy and numeracy never approached Roman levels. It is also likely that the post-Han decline in information technology was less severe than the West's post-Roman decline. Historically important as they must have been, the Chinese variations around the score of 0.02 points are probably too small to register on the index of social development.

The earliest evidence for symbolic notations in China comes from Jiahu around 6250 BCE, and there is enough evidence to suggest some continuity in practices across the next 5,000 years (Demattè 2010). It is only around 1300 BCE, however, that Chinese use of writing and mathematical notation seems comparable to that seen in Mesopotamia around 3000 BCE, earning 0.01 points. Across the next thousand years the evidence suggests a fairly constant process of expansion of the use of symbolic systems, from oracle bones through inscriptions of bronze vessels to extensive painting in ink on bamboo strips and silk. However, the scores are so tiny that the improvements only register on the social development index as a jump from 0.01 to 0.02 points, which I place around 600 BCE.

The evidence for energy capture, city size/organization, war-making capacity, and information technology that I have gathered can very obviously be interpreted in multiple ways. The key terms behind my concept of social development could be defined in different ways; I could have made different underlying assumptions; I could have used different traits; and I could have found other ways to calculate the scores. Long chains of argument and calculation were involved in generating the index. As a result, another inquirer could have come up with a different set of social development scores; indeed, it is highly unlikely that any other inquirer would have come up with exactly the same set of scores as I have done. For that matter, if I were to start the exercise of calculating social development scores all over again, I would myself probably come up with different numbers.

Consequently, there is little to be gained from asking whether the index is right. No index can ever be "right," whether we mean that in the strong sense that every one of the 530 numbers in Tables 11 and 12 perfectly corresponds to reality, or in the weak sense that all experts would agree on them. The scores I have calculated are bound to be wrong; the only useful question to ask is *how* wrong they are. Are they so wrong that the basic shape of history depicted in Graph 2 on p. 20 above is misleading, meaning that the whole of *Why the West Rules—For Now* (Morris 2010) is fatally flawed? Or are the errors in fact fairly trivial?

Table 11: Western social development scores, trait by trait, 14,000 BCE-2000 CE

	Energy Capture	Organization	War-making Capacity	Information Technology	Total
14,000 BCE	4.36	0.00	0.00	0.00	4.36
13,000 BCE	4.36	0.00	0.00	0.00	4.36
12,000 BCE	4.90	0.00	0.00	0.00	4.90
11,000 BCE	5.45	0.00	0.00	0.00	5.45
10,000 BCE	5.45	0.00	0.00	0.00	5.45
9000 BCE	5.99	0.00	0.00	0.00	5.99
8000 BCE	6.54	0.00	0.00	0.00	6.54
7000 BCE	7.08	0.01	0.00	0.00	7.09
6000 BCE	7.63	0.03	0.00	0.00	7.66
5000 BCE	8.72	0.04	0.00	0.00	8.76
4000 BCE	10.90	0.05	0.00	0.00	10.95
3500 BCE	11.99	0.09	0.00	0.00	12.98

3000 BCE	13.08	0.42	0.01	0.01	13.52
2500 BCE	15.26	0.47	0.01	0.01	16.29
2250 BCE	17.44	0.33	0.01	0.01	17.79
2000 BCE	18.52	0.56	0.01	0.02	19.11
1750 BCE	20.65	0.61	0.02	0.02	21.30
1500 BCE	22.34	0.70	0.03	0.02	23.08
1400 BCE	22.88	0.75	0.03	0.02	23.68
1300 BCE	23.43	0.75	0.03	0.02	24.23
1200 BCE	22.88	0.75	0.04	0.02	23.69
1100 BCE	22.34	0.47	0.03	0.01	22.85
1000 BCE	21.79	0.47	0.03	0.01	22.30
900 BCE	22.34	0.47	0.04	0.02	22.87
800 BCE	22.88	0.70	0.05	0.02	23.65
700 BCE	23.43	0.94	0.07	0.02	24.45
600 BCE	23.97	1.17	0.07	0.02	25.23
500 BCE	25.06	1.40	0.08	0.03	26.56
400 BCE	26.15	1.40	0.09	0.03	27.67
300 BCE	28.33	1.40	0.09	0.03	29.85
200 BCE	29.42	2.81	0.10	0.03	32.36
100 BCE	31.06	3.75	0.11	0.04	35.50
1 BCE/CE	33.78	9.36	0.12	0.04	43.30
100 CE	33.78	9.36	0.12	0.04	43.30
200 CE	32.69	9.36	0.11	0.04	42.20
300 CE	31.60	7.49	0.10	0.03	39.22
400 CE	31.06	7.49	0.09	0.03	38.67
500 CE	30.51	4.23	0.07	0.03	34.84
600 CE	28.33	1.41	0.04	0.02	29.80
700 CE	27.24	1.17	0.04	0.02	28.47
800 CE	27.24	1.64	0.04	0.02	28.94
900 CE	27.24	1.64	0.05	0.02	28.95
1000 CE	28.33	1.87	0.06	0.02	30.28
1100 CE	28.33	2.34	0.07	0.02	30.76
1200 CE	28.88	2.34	0.08	0.04	31.33
1300 CE	29.42	3.75	0.09	0.04	33.31
1400 CE	28.33	1.17	0.11	0.04	29.65
1500 CE	29.42	3.75	0.13	0.05	33.35
1600 CE	31.06	3.75	0.18	0.07	35.60
1700 CE	34.87	5.62	0.35	0.14	40.98
1800 CE	41.41	8.43	0.50	0.29	50.63
1900 CE	100.25	61.80	5.00	3.19	170.24
2000 CE	250.00	156.37	250.00	250.00	906.37

Table 12: Eastern social development scores, trait by trait, 14,000 BCE-2000 CE

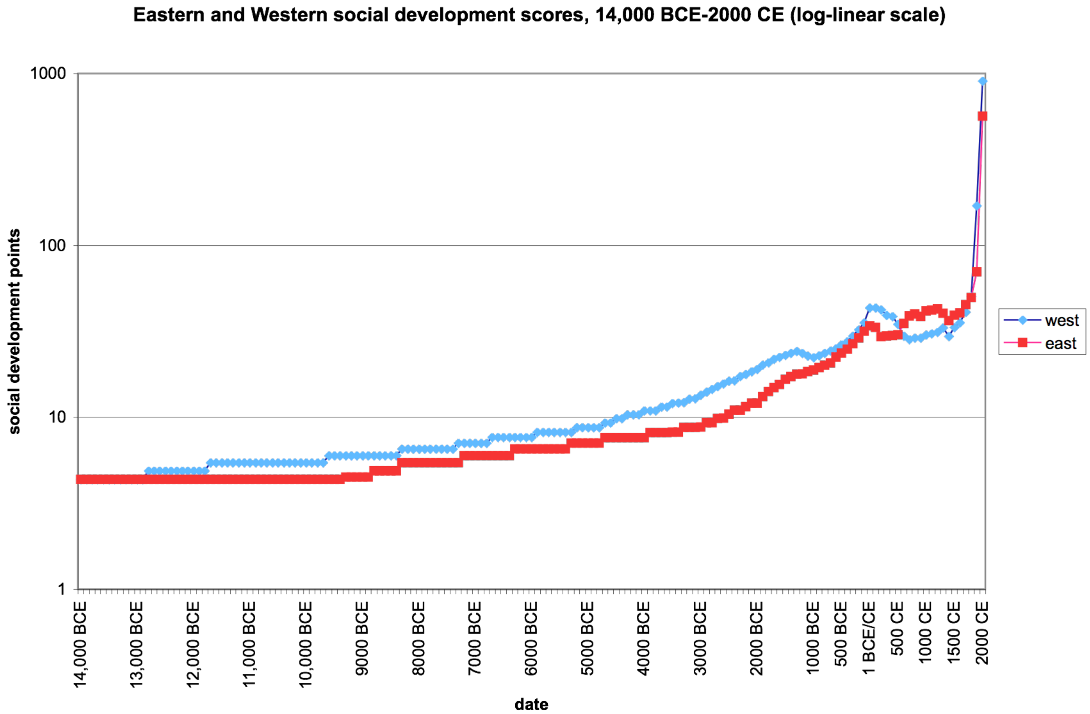
	Energy Capture	Organization	War-making Capacity	Information Technology	Total
14,000 BCE	4.36	0.00	0.00	0.00	4.36
13,000 BCE	4.36	0.00	0.00	0.00	4.36
12,000 BCE	4.36	0.00	0.00	0.00	4.36
11,000 BCE	4.36	0.00	0.00	0.00	4.36
10,000 BCE	4.36	0.00	0.00	0.00	4.36
9000 BCE	4.90	0.00	0.00	0.00	4.90
8000 BCE	5.45	0.00	0.00	0.00	5.45
7000 BCE	5.99	0.00	0.00	0.00	5.99
6000 BCE	6.54	0.00	0.00	0.00	6.54
5000 BCE	7.08	0.00	0.00	0.00	7.08
4000 BCE	7.63	0.00	0.00	0.00	7.63
3500 BCE	8.17	0.02	0.00	0.00	8.19
3000 BCE	8.72	0.05	0.00	0.00	8.77
2500 BCE	10.35	0.09	0.00	0.00	10.44
2250 BCE	11.44	0.13	0.00	0.00	11.57
2000 BCE	11.99	0.10	0.00	0.00	12.09
1750 BCE	14.17	0.22	0.00	0.00	14.39
1500 BCE	16.35	0.33	0.01	0.00	16.69
1400 BCE	16.89	0.33	0.01	0.00	17.23
1300 BCE	17.44	0.33	0.01	0.01	17.79
1200 BCE	17.44	0.47	0.02	0.01	17.94
1100 BCE	17.98	0.47	0.02	0.01	18.48
1000 BCE	18.52	0.33	0.03	0.01	18.89
900 BCE	19.07	0.37	0.03	0.01	19.48
800 BCE	19.61	0.42	0.02	0.01	20.06
700 BCE	20.16	0.51	0.02	0.01	20.70
600 BCE	21.79	0.61	0.03	0.02	22.45
500 BCE	22.88	0.75	0.04	0.02	23.69
400 BCE	23.97	0.94	0.05	0.02	24.98
300 BCE	24.52	1.17	0.06	0.02	26.87
200 BCE	26.15	2.81	0.07	0.02	29.05
100 BCE	27.79	3.45	0.08	0.02	31.64
1 BCE/CE	29.42	4.68	0.08	0.02	34.20
100 CE	29.42	3.93	0.08	0.02	33.44
200 CE	28.33	1.12	0.07	0.02	29.54
300 CE	28.33	1.31	0.07	0.02	29.73
400 CE	28.33	1.87	0.07	0.02	29.99
500 CE	28.33	1.87	0.08	0.02	30.30
600 CE	29.42	5.63	0.09	0.02	35.16
700 CE	29.42	9.36	0.11	0.02	38.91
800 CE	30.51	9.36	0.07	0.02	39.96

900 CE	31.06	7.00	0.07	0.02	38.69
1000 CE	32.15	9.36	0.08	0.02	41.61
1100 CE	32.69	9.36	0.09	0.02	42.17
1200 CE	33.23	9.36	0.09	0.04	42.73
1300 CE	32.69	7.50	0.11	0.04	40.34
1400 CE	31.06	4.68	0.12	0.06	36.45
1500 CE	32.69	6.35	0.10	0.06	39.20
1600 CE	33.78	6.55	0.12	0.07	40.52
1700 CE	35.96	6.09	0.15	0.09	45.29
1800 CE	39.23	10.30	0.12	0.13	49.78
1900 CE	53.40	16.39	1.00	0.30	71.09
2000 CE	113.33	250.00	12.50	189.00	564.83

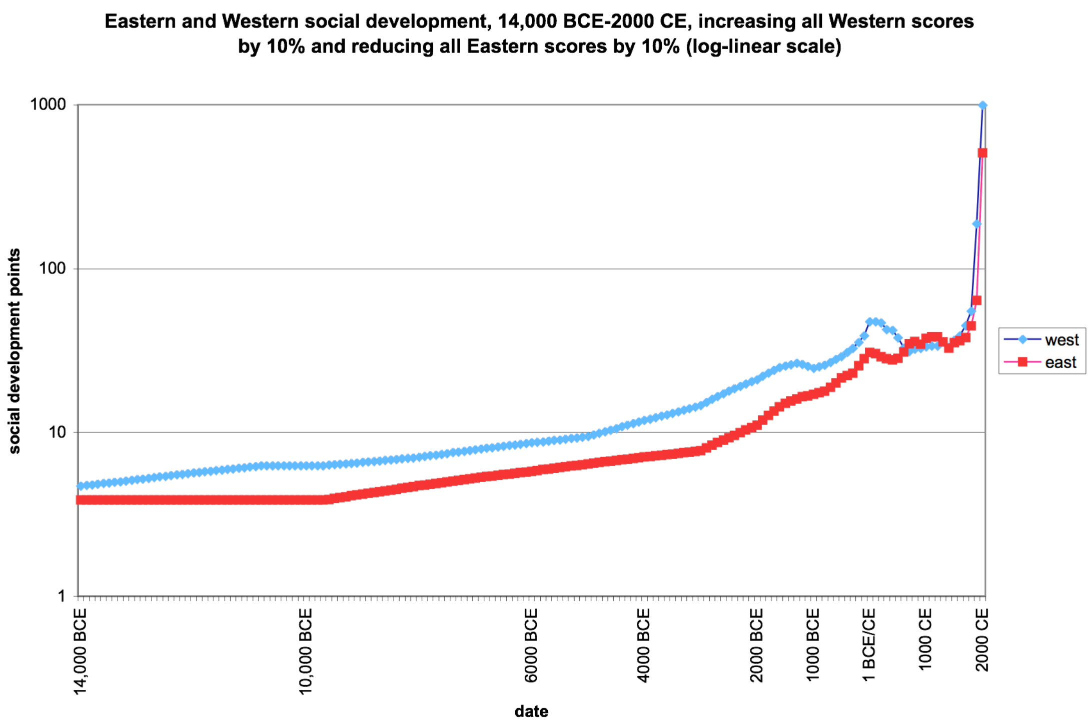
The only way to know for sure will be for other historians to work through the evidence I have collected on this website, or to show why we should be looking at different sets of evidence, and to test my arguments. I suggested in *Why the West Rules—For Now* (Morris 2010: 640-44) that we can in fact be fairly precise about just how wrong the scores in the index can afford to be. If they are typically within 10 percent of the numbers other analysts calculate, the basic shape of the pattern I am trying to explain will remain them same. If they are typically 15 percent wide of the mark, that may—depending on the details—change the shape of the development curves enough to falsify my argument. If they are wrong by 20 percent or more, that definitely falsifies my argument.

According to the index, shown on a log-linear scale in Graph 60, Western social development pulled ahead of the East's after 14,000 BCE. The East slowly caught up, especially after 2000 BCE and through most of the first millennium BCE the West's lead was narrow. Around 100 BCE the west pulled further ahead again, but in 541 CE the Eastern line for the first time rose above the Western. The Eastern score then stayed ahead till 1773. Western development has been higher than Eastern for 92.5 percent of the time since the end of the Ice Age.

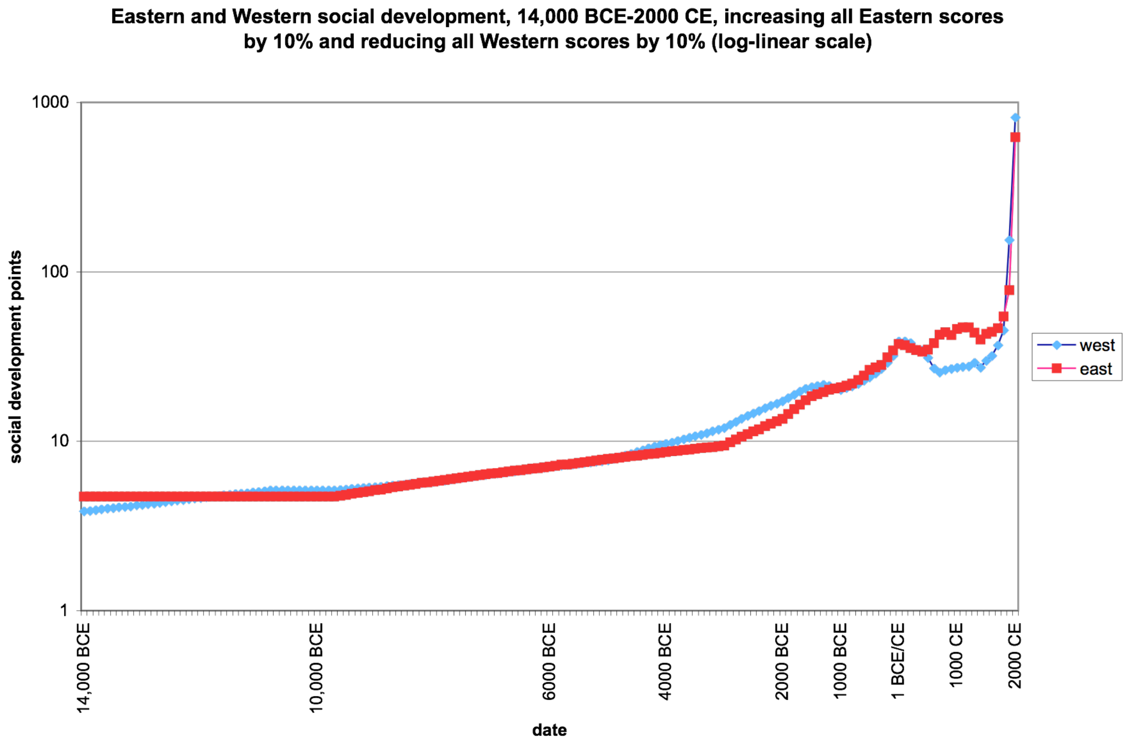
Graph 61 shows on a log-linear scale shows what the Eastern and Western trends would look like if I have consistently underestimated Western development scores by 10 percent and overestimated Eastern scores by the same amount (i.e., the graph inflates the actual Western estimates by 10 percent and deflates the Eastern estimates by 10 percent), and Graph 62 shows the outcome if I have made the opposite error, underestimating Eastern development scores by 10 percent and overestimated Western scores by the same amount.



Graph 60. Eastern and Western social development scores, 14,000 BCE-2000 CE, on a log-linear scale



Graph 61. Eastern and Western social development scores, 14,000 BCE-2000 CE, on a log-linear scale, increasing all Western scores 10 percent and reducing all Eastern scores 10 percent

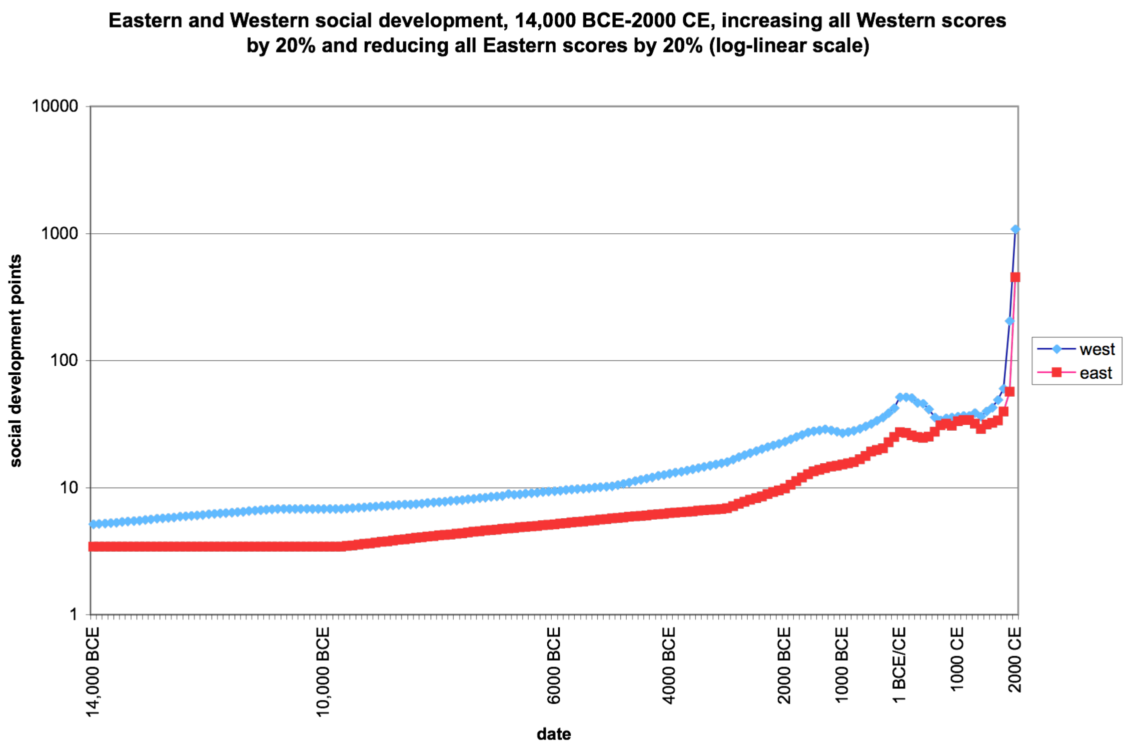


Graph 62. Eastern and Western social development scores, 14,000 BCE-2000 CE, on a log-linear scale, decreasing all Western scores 10 percent and increasing all Eastern scores 10 percent

The first point to note is how much these scores strain credibility. Graph 61, raising Western and lowering Eastern scores by 10 percent, requires us to accept that in 1400 CE, as Zheng He was preparing to set sail on the Indian Ocean, the West was more developed than the East; it also means that when Hannibal led his elephants to attack Rome in 218 BCE, Western development was already higher than the East's would be in Zheng's time. And as if these conclusions were not peculiar enough, it also tells us that the West was more developed when Julius Caesar was murdered in 44 BCE than the East was when China's emperor Qianlong rejected Lord Macartney's trade embassy in 1793 CE. None of these conclusions fits well with the mass of historical evidence available.

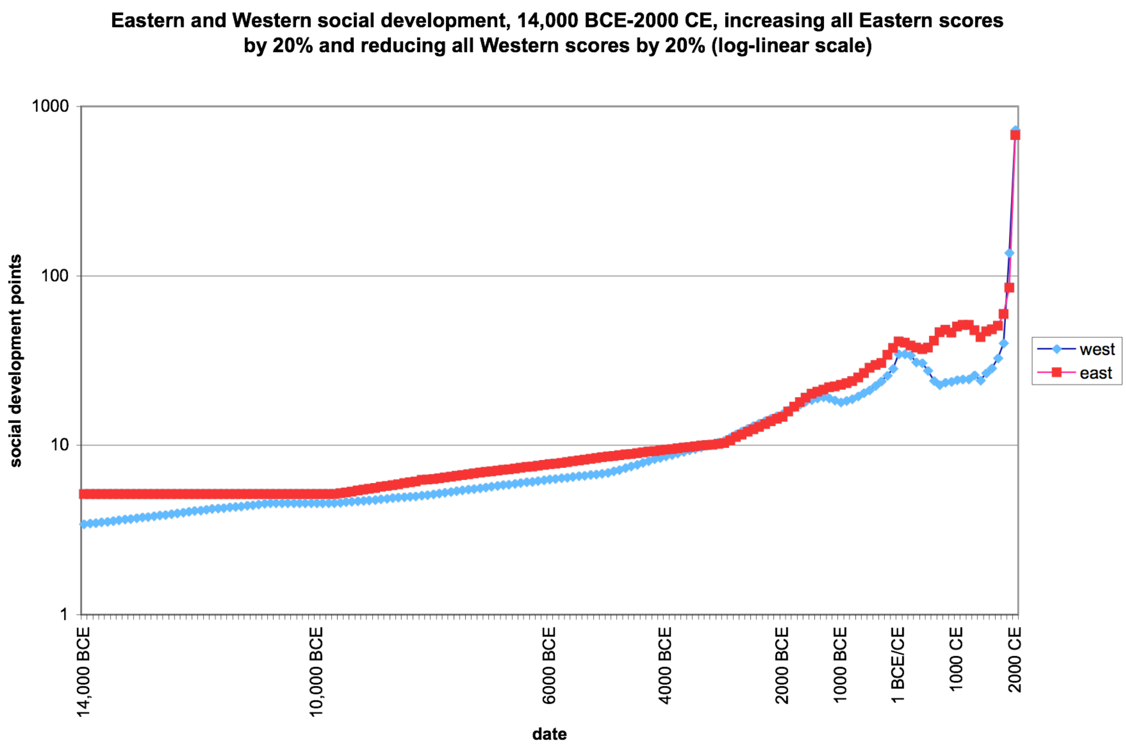
Graph 62 is perhaps even more peculiar. The development score it gives to the West in 700 CE, for instance, when the Arabs ruled a vast caliphate from Damascus, is lower than that for the East in the age of Confucius, which cannot be right; and it would make the Western score in 1800 CE, when the industrial revolution was already underway and the British and French Empires straddled vast reaches of the globe, lower than the Eastern scores under the Song dynasty in 1000-1200 CE, which seems even less likely.

Yet even if historians could swallow such odd conclusions, the shapes of history as represented in Graphs 61 and 62 are still not different enough from that in Graph 60 to change the basic pattern that needs explaining. Short-term accident theories (Morris 2010: 18-21) remain inadequate because even in Graph 62 the West's score is still higher for most of the period since the end of the Ice Age (although "most" now means 56 percent rather than 92.5 percent); so too long-term lock-in theories (Morris 2010: 11-18), because even in Graph 61 the East does take the lead for seven centuries. The pattern produced by the scores that I have calculated—of Western lead for most of the last 15,000 years, interrupted for 1,200 years by an "Eastern Age"—remains intact.



Graph 63. Eastern and Western social development scores, 14,000 BCE-2000 CE, on a log-linear scale, increasing all Western scores 20 percent and reducing all Eastern scores 20 percent

To change the fundamental patterns in need of explanation, we would have to conclude that my estimates are in fact 20 percent wide of the mark. Graph 63 shows how history would look if I have consistently underestimated Western development scores by 20 percent and overestimated Eastern scores by the same amount; Graph 64 shows the outcome if I have underestimated Eastern development scores by 20 percent and overestimated Western scores by the same amount.



Graph 64. Eastern and Western social development scores, 14,000 BCE-2000 CE, on a log-linear scale, decreasing all Western scores 20 percent and increasing all Eastern scores 20 percent

This time the patterns are very different. In Graph 63 the Western score is always higher than the eastern, making long-term lock-in theories seem very plausible and also invalidating the claim that I make throughout *Why the West Rules—For Now* that social development changes the meaning of geography. Graph 64, by contrast, effectively reverses the conclusions of my actual index, having the East lead 90 percent of the time since the Ice Age.

If either Graph 63 or Graph 64 is correct, everything in *Why the West Rules—For Now* is wrong. We can be confident, though, that they are not correct. Graph 63, raising Western scores and reducing Eastern scores by 20 percent, tells us that imperial Rome's development in 1 BCE/CE was only 5 points behind industrial Japan's in 1900, which cannot be true. Graph 64, on the other hand, raising Eastern scores and reducing Western scores by 20 percent, means that Eastern development was higher in pre-Shang times than Western would be under the Persian Empire; that the West only caught up with the East in 1828 CE, on the eve of the Opium War; and that Western rule has already ended (in 2003). None of this seems credible.

Hence my conclusion that (a) the margin of error in my estimates is probably less than 10 percent and definitely less than 20 percent and (b) even if the margin of error does rise to 10 percent, the basic historical patterns I am trying to explain still hold good. It remains for other analysts to determine whether my conclusion is correct.

13 Discussion

Why the West rules has emerged as one of the most intense debates in English-language history and the social sciences in the early 21st century (e.g., Acemoglu and Robinson, forthcoming; Allen 2009b; Allen et al. 2005; Arrighi 2007; Arrighi et al. 2003; Bengtsson et al. 2005; Clark 2007; Diamond 1997; Frank 1998; Goldstone 2009; Goody 1996, 2004, 2007, 2009; Hobson 2004; Landes 1998; Maddison 2003, 2005, 2007a, 2007b; North et al. 2009; Pomeranz 2000). China's explosive economic growth, the likelihood of its emergence as a military great power in the 2010s-2020s, and a perception that the West is in decline (e.g., Ferguson 2007; Jacques 2009; Halper 2010) seem to lie behind this spike in interest.

However, there is little agreement on how to answer the question, or even on what exactly the question means. I proposed in *Why the West Rules—For Now* (Morris 2010: 11-21) that we can conveniently divide the theories into two broad types. The first, which I called the long-term lock-in models, suggests that some factor made East and West unalterably different in the distant past, determining that the West would come to dominate the globe; the second, the short-term accident models, suggests that there have always been far more similarities than differences between East and West, and that the factors that gave the West dominance only emerged very recently, largely by accident. Long-term lock-in theories often seem to imply that Western rule is a permanent feature of the world; short-term accident accounts often seem to imply that it is very temporary, and will soon end.

The problem, I suggested, is that champions of each kind of theory tend to look at different sorts of evidence and define the key terms in different ways, with the result that they often end up talking past each other. The main goal of constructing an index of social development was to make the discussion explicit: the fact that I am quantifying East-West does not necessarily make my analysis any more objective than qualitative accounts, but it does at least make it more explicit, by forcing me to make decisions about what I measure, how I measure it, and what importance I attach to the scores (Morris 2010: 143-60). Such explicitness makes the arguments more transparent, allowing the champions to rival theories to get straight to the task of showing why they think I have measured the wrong things, done the measuring badly, and/or misunderstood the results.

I emphasized throughout *Why the West Rules—For Now* and again in this website that constructing an index of social development is chainsaw art: the key question to ask at each point is not whether the index is right, because almost by definition it cannot be, but whether it is so badly wrong that it has distorted the shape of history. I (obviously) do not think the index is that badly wrong. Its margin of error may well reach 10 percent but does not reach 20 percent, and the patterns in the history of social development are sufficiently robust that errors of ± 10 percent do not significantly change them.

Graph 2 on p. 20 above shows the social development scores across the last 16,000 years. Two points stand out: (1) the Eastern and Western curves are very similar, and (2) both curves are almost flat until roughly 1800 CE, when they take almost 90° turns and rise very sharply. On the face of it, these observations seem to support short-term accident theories much better than long-term lock-in ones: East and West are very similar, and something very dramatic happened just 200 years ago.

However, the second of these observations—the abrupt acceleration in scores around 1800 CE—largely explains the first (the similarity of the Eastern and Western curves): in order to fit the West's 2000 CE score of 906 points onto a linear-linear graph, all earlier scores have to be compressed to the point that their differences disappear from sight. Graph 60 shows the same data on a log-linear scale (explained in Morris 2010: 162-66), and four more points now stand out.

First, the impression that Graph 2 created, of almost no change before 1800 CE, is misleading. Economists often suggest that this was indeed the case, often nowadays illustrating their point with Gregory Clark's graph (p. 75 above) showing a random walk around bare subsistence until 1800 CE then an abrupt takeoff. Graph 60, however, shows that social development has rarely stagnated; it has been rising almost all the time since the end of the Ice Age, at an exponential rate, with the exponent increasing. What has happened since 1800 CE has been an extreme example of the growth that has been underway for thousands of years, rather than a complete break with previous human history.

Second, the increase in social development scores since the end of the Ice Age has not been constant: there have been periods (sometimes centuries-long) of stagnation and decline.

Third, despite their general similarities, the Eastern and Western curves do have important differences: the Western social development score has been higher than the Eastern for 90 percent of the time since 14,000 BCE.

Finally, we should also note that the Western score has not been higher than the Eastern all of the time. The West's lead has fluctuated, and for 1,200 years, from roughly 550 through 1750 CE, the East's score was higher than the West's.

The social development index shows us what we will need to explain if we are to answer the question of why the West rules. The index does not itself do the explaining, but it does show that any theory that cannot account for all six of these observations—the general similarity of Eastern and Western scores, the abrupt takeoff in both regions after 1800 CE, the general trend for social development scores to rise over time, the occasional stagnation and decline of scores, the West's long-term lead, and the millennium-long Eastern interruption of it—will fail as an explanation.

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